Template Method

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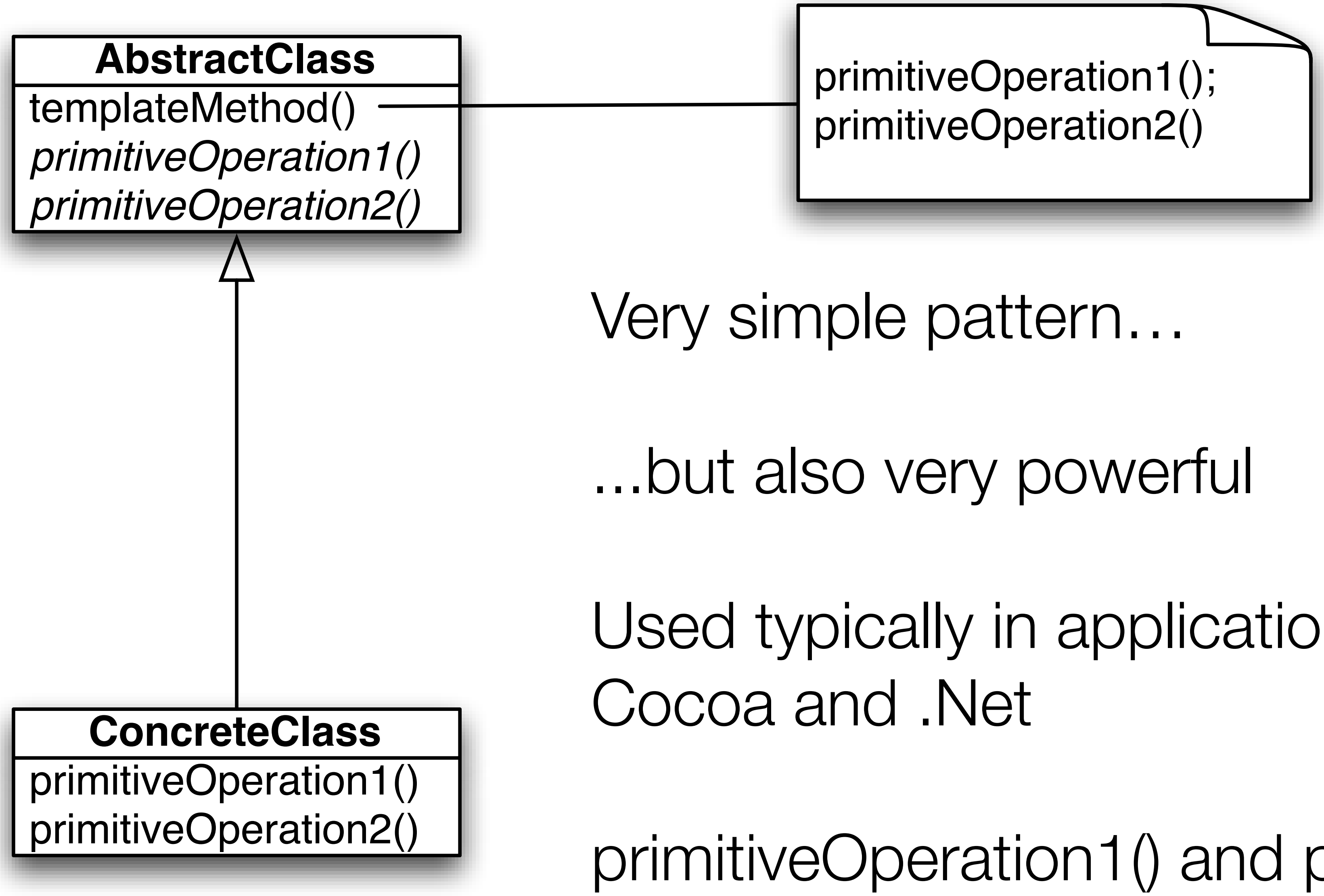
Lecture Goals

- Cover Material from Chapter 8 of the Design Patterns Textbook
    - Template Method Pattern

Template Method: Definition

- The Template Method Pattern defines the skeleton of an algorithm in a method, deferring some steps to subclasses. Template Method lets subclasses **redefine** certain steps of an algorithm without changing the algorithm's **structure**
  - Template Method defines the steps of an algorithm and allows subclasses to provide the implementation for one or more steps
    - Makes the algorithm abstract
      - Each step of the algorithm is represented by a method
    - Encapsulates the details of most steps
      - Steps (methods) handled by subclasses are declared abstract
      - Shared steps (concrete methods) are placed in the same class that has the template method, allowing for code re-use among the various subclasses

Template Method: Structure



Very simple pattern…

...but also very powerful

Used typically in application frameworks, e.g. Cocoa and .Net

primitiveOperation1() and primitiveOperation2() are sometimes referred to as **hook methods** as they allow subclasses *to hook* their behavior *into* the service provided by AbstractClass

Example: Tea and Coffee

- The book returns to the Starbuzz example and shows the training guide for baristas and, in particular, the recipes for making coffee and tea
  - Coffee
    - Boil water
    - Brew coffee in boiling water
    - Pour coffee in cup
    - Add sugar and milk
  - Tea
    - Boil water
    - Steep tea in boiling water
    - Pour tea in cup
    - Add lemon

Coffee Implementation

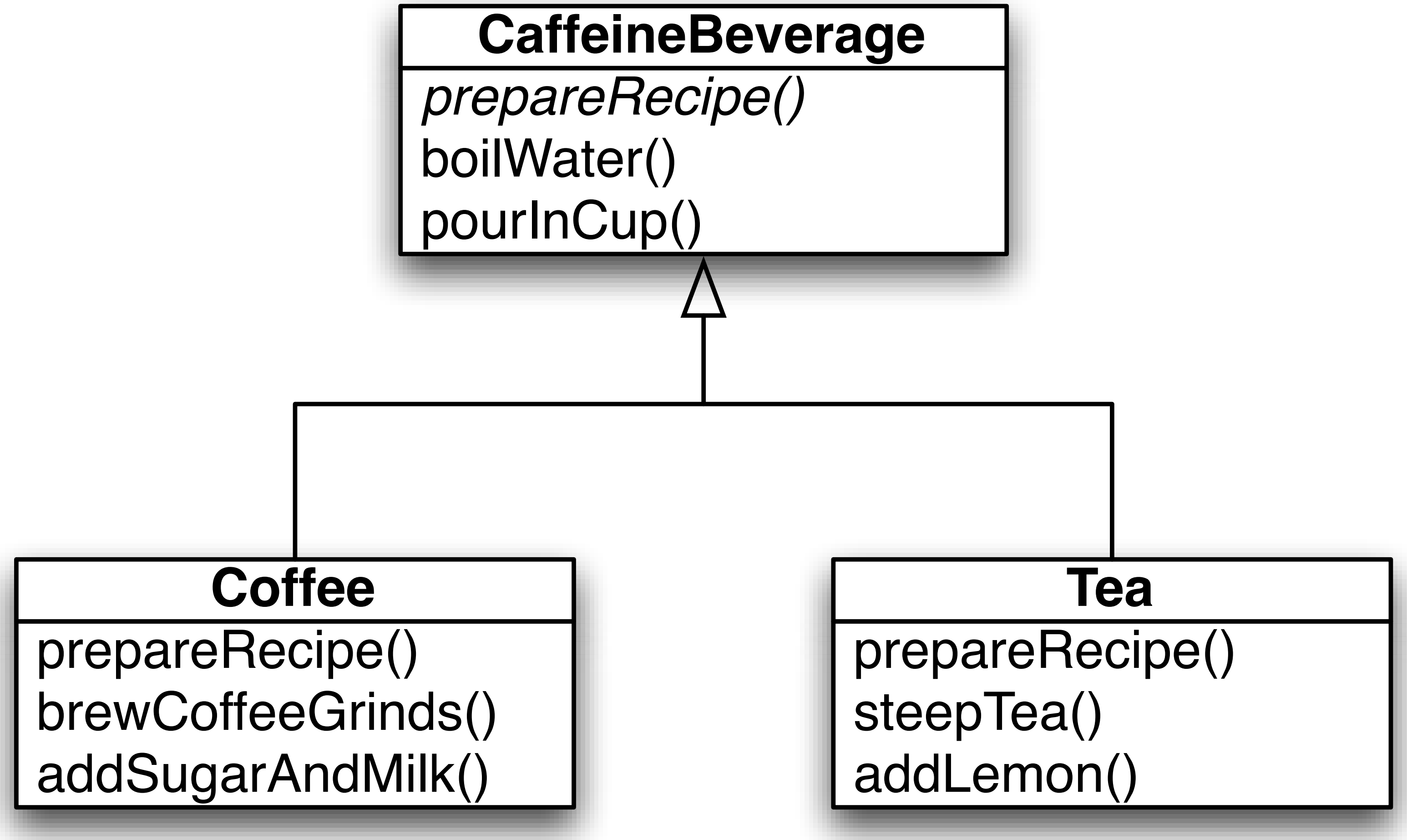
```java
public class Coffee {

    void prepareRecipe() {
        boilWater();
        brewCoffeeGrinds();
        pourInCup();
        addSugarAndMilk();
    }

    public void boilWater() {
        System.out.println("Boiling water");
    }

    public void brewCoffeeGrinds() {
        System.out.println("Dripping Coffee through filter");
    }

    public void pourInCup() {
        System.out.println("Pouring into cup");
    }

    public void addSugarAndMilk() {
        System.out.println("Adding Sugar and Milk");
    }
}

```

Tea Implementation

```java
public class Tea {

    void prepareRecipe() {
        boilWater();
        steepTeaBag();
        pourInCup();
        addLemon();
    }

    public void boilWater() {
        System.out.println("Boiling water");
    }

    public void steepTeaBag() {
        System.out.println("Steeping the tea");
    }

    public void addLemon() {
        System.out.println("Adding Lemon");
    }

    public void pourInCup() {
        System.out.println("Pouring into cup");
    }
}

```

Code Duplication!

- We have code duplication occurring in these two classes
  - boilWater() and pourInCup() are exactly the same
- Lets get rid of the duplication



Similar algorithms

- The structure of the algorithms in prepareRecipe() is similar for Tea and Coffee
    - We can improve our code further by making the code in prepareRecipe() more abstract
        - brewCoffeeGrinds() and steepTea() ⇒ brew()
        - addSugarAndMilk() and addLemon() ⇒ addCondiments()
- Excellent, now all we need to do is specify this structure in CaffeineBeverage.prepareRecipe() and make it such that subclasses can’t change the structure
    - How do we do that?
        - Answer: By convention OR by using the keyword “final” in languages that support it

CaffeineBeverage Implementation

```java
public abstract class CaffeineBeverage {

    final void prepareRecipe() {
        boilWater();
        brew();
        pourInCup();
        addCondiments();
    }

    abstract void brew();

    abstract void addCondiments();

    void boilWater() {
        System.out.println("Boiling water");
    }

    void pourInCup() {
        System.out.println("Pouring into cup");
    }
}
```

Note: use of final keyword for prepareReceipe()

brew() and addCondiments() are abstract and must be supplied by subclasses

boilWater() and pourInCup() are specified and shared across all subclasses

Coffee And Tea Implementations

```java
public class Coffee extends CaffeineBeverage {
    public void brew() {
        System.out.println("Dripping Coffee through filter");
    }
    public void addCondiments() {
        System.out.println("Adding Sugar and Milk");
    }
}

public class Tea extends CaffeineBeverage {
    public void brew() {
        System.out.println("Steeping the tea");
    }
    public void addCondiments() {
        System.out.println("Adding Lemon");
    }
}

```

Nice and Simple!

What have we done?

- Took two separate classes with separate but similar algorithms
- Noticed duplication and eliminated it by introducing a superclass
- Made steps of algorithm more abstract and specified its structure in the superclass
    - Thereby eliminating another “implicit” duplication between the two classes
- Revised subclasses to implement the abstract (unspecified) portions of the algorithm… in a way that made sense for them

Comparison: Template Method (TM) vs. No TM

- **No Template Method**
- Coffee and Tea each have own copy of algorithm
- Code is duplicated across both classes
- A change in the algorithm would result in a change in both classes
- Not easy to add new caffeine beverage
- Knowledge of algorithm distributed over multiple classes

- **Template Method**
- CaffeineBeverage has the algorithm and protects it
- CaffeineBeverage shares common code with all subclasses
- A change in the algorithm likely impacts only CaffeineBeverage
- New caffeine beverages can easily be plugged in
- CaffeineBeverage centralizes knowledge of the algorithm; subclasses plug in missing pieces

The Book’s Hook

- Previously I called the abstract methods that appear in a template method “hook” methods
    - The book refers to hook methods as well, but they make the following distinction: a hook method is a concrete method that appears in the AbstractClass that has an empty method body (or a mostly empty method body, see example next slide), i.e.
        - public void hook() {}
    - Subclasses are free to override them but don’t have to since they provide a method body, albeit an empty one
        - In contrast, a subclass is forced to implement abstract methods that appear in AbstractClass
- Hook methods, thus, should represent optional parts of the algorithm

Adding a Hook to CaffeineBeverage

```java
public abstract class CaffeineBeverageWithHook {

    void prepareRecipe() {
        boilWater();
        brew();
        pourInCup();
        if (customerWantsCondiments()) {
            addCondiments();
        }
    }

    abstract void brew();

    abstract void addCondiments();

    void boilWater() {
        System.out.println("Boiling water");
    }

    void pourInCup() {
        System.out.println("Pouring into cup");
    }

    boolean customerWantsCondiments() {
        return true;
    }
}

```

prepareRecipe() altered to have a hook method: customerWantsCondiments()

This method provides a mostly empty method body that subclasses can override

To make the distinction between hook and non-hook methods more clear, you can add the “final” keyword to all concrete methods that you don’t want subclasses to touch

Adding a Hook to Coffee

Demonstration

```java
import java.io.*;

public class CoffeeWithHook extends CaffeineBeverageWithHook {

    public void brew() {
        System.out.println("Dripping Coffee through filter");
    }

    public void addCondiments() {
        System.out.println("Adding Sugar and Milk");
    }

    public boolean customerWantsCondiments() {

        String answer = getUserInput();

        if (answer.toLowerCase().startsWith("y")) {
            return true;
        } else {
            return false;
        }
    }

    private String getUserInput() {
        String answer = null;

        System.out.print("Would you like milk and sugar with your coffee (y/n)? ");

        BufferedReader in = new BufferedReader(new InputStreamReader(System.in));
        try {
            answer = in.readLine();
        } catch (IOException ioe) {
            System.err.println("IO error trying to read your answer");
        }
        if (answer == null) {
            return "no";
        }
        return answer;
    }
}
```

New Design Principle: Hollywood Principle

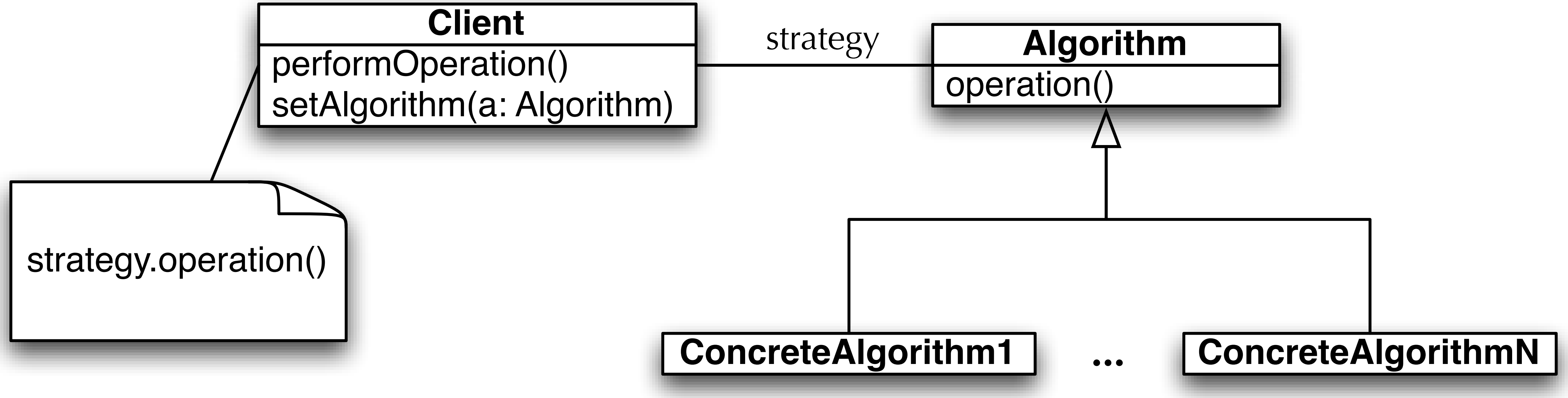
- Don’t call us, we’ll call you
- Or, in OO terms, high-level components call low-level components, not the other way around
  - In the context of the template method pattern, the template method lives in a high-level class and invokes methods that live in its subclasses
- This principle is similar to the dependency inversion principle we discussed back in lecture 21 (Factory pattern): “Depend upon abstractions. Do not depend upon concrete classes.”
  - Template method encourages clients to interact with the abstract class that defines template methods as much as possible; this discourages the client from depending on the template method subclasses

Template Methods in the Wild

- Template Method is used a lot since it’s a great design tool for creating frameworks
  - the framework specifies how something should be done with a template method
  - that method invokes abstract and hook methods that allow client-specific subclasses to “hook into” the framework and take advantage of/influence its services
- Examples in the Java API
  - Sorting using compareTo() method
  - Frames in Swing
  - Applets
- Demonstration

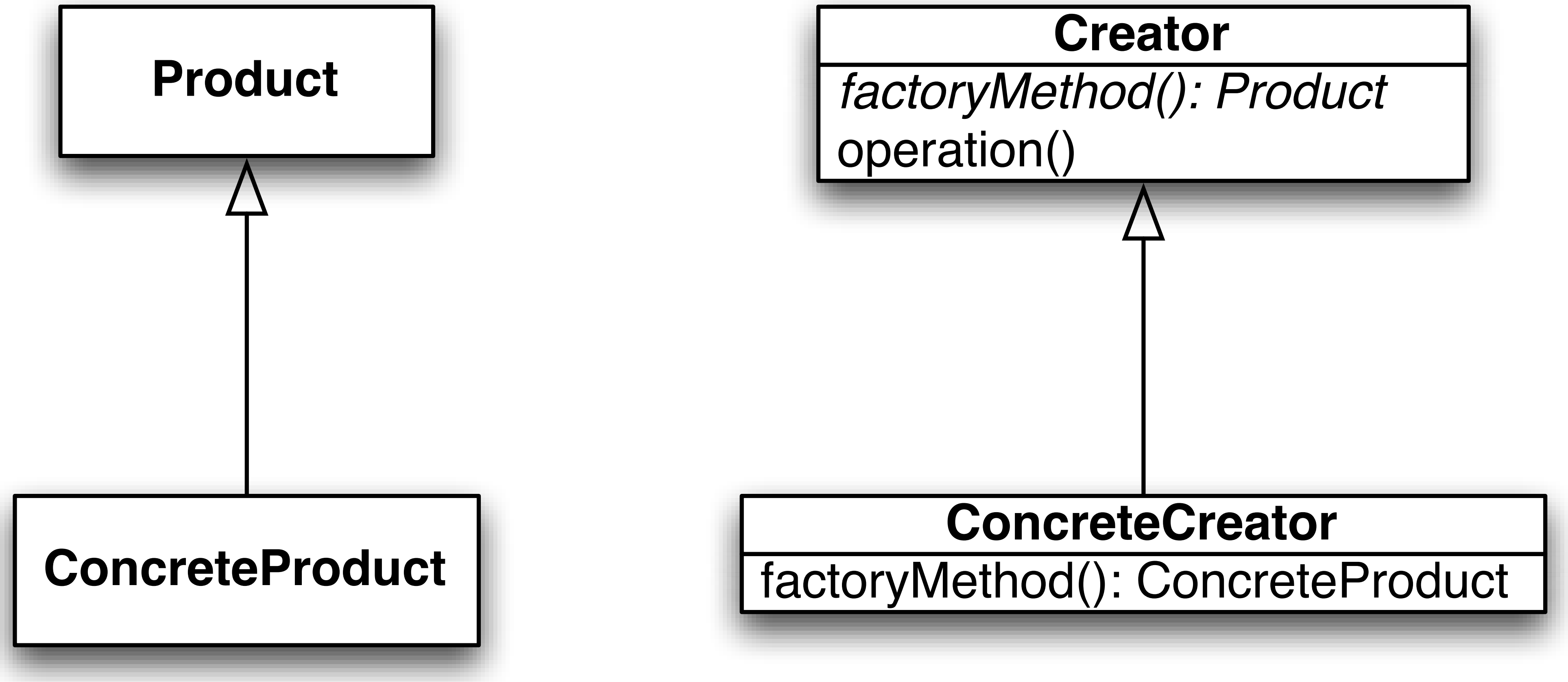
Template Method vs. Strategy (I)

- Both Template Method and Strategy deal with the encapsulation of algorithms
  - Template Method focuses encapsulation on the steps of the algorithm
  - Strategy focuses on encapsulating entire algorithms
  - You can use both patterns at the same time if you want
- Strategy Structure



Template Method vs. Strategy (II)

- Template Method encapsulate the details of algorithms using inheritance
  - Factory Method can now be seen as a specialization of the Template Method pattern



- In contrast, Strategy does a similar thing but uses composition/delegation

Template Method vs. Strategy (III)

- Because it uses inheritance, Template Method offers code reuse benefits not typically seen with the Strategy pattern
- On the other hand, Strategy provides run-time flexibility because of its use of composition/delegation
  - You can switch to an entirely different algorithm when using Strategy, something that you can’t do when using Template Method

Coming Up Next

- Lecture 25: Iterator and Composite
  - Read Chapter 9 of the Design Patterns Textbook
- Lecture 26: State and Proxy
  - Read Chapters 10 and 11 of the Design Patterns Textbook