Design Patterns

Template Method Pattern*

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The Template Method Pattern

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.

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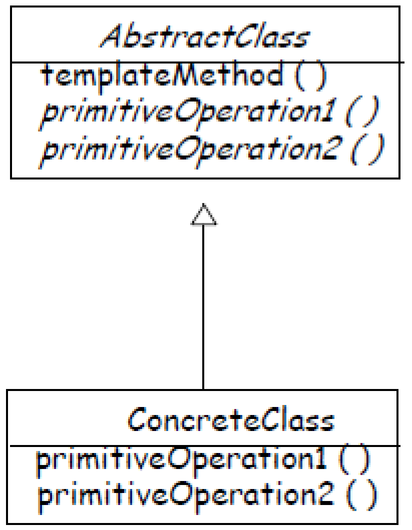
The Template Method Pattern

You have an abstract class that is the base class of a hierarchy, and the behavior that is common to all objects in the hierarchy is implemented in the abstract class and other details are left to the individual subclasses.



Template Method allows you to define a skeleton of an algorithm in an operation and defer some of the steps to subclasses. Template Method lets subclasses redefine certain steps of an algorithm without changing the algorithm's structure.

Time for some caffeine….

Starbuzz Coffee Barista Training Manual

Baristas! Please follow these recipes precisely when preparing Starbuzz beverages.

<u>Starbuzz Coffee Recipe</u>

(1) Boil some water
(2) Brew coffee in boiling water
(3) Pour coffee in cup
(4) Add sugar and milk

<u>Starbuzz Tea Recipe</u>

(1) Boil some water
(2) Steep tea in boiling water
(3) Pour tea in cup
(4) Add lemon

The recipe for coffee and tea are very similar!

Whipping up some Coffee in 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 thru filter”);
      }
      public void pourInCup  ( ) {
            System.out.println(“Pouring into cup”);
      }
      public void addSugarAndMilk ( ) {
            System.out.println (“Adding Sugar and Milk” );
      }
}
```

Recipe for coffee - each step is implemented as a separate method.

Each of these methods implements one step of the algorithm. There's a method to boil the water, brew the coffee, pour the coffee in the cup, and add sugar and milk.

And now for the Tea….

```
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 pourInCup  ( ) {
           System.out.println(“Pouring into cup”);
     }
     public void addLemon ( ) {
           System.out.println (“Adding Lemon” );
     }
}
```

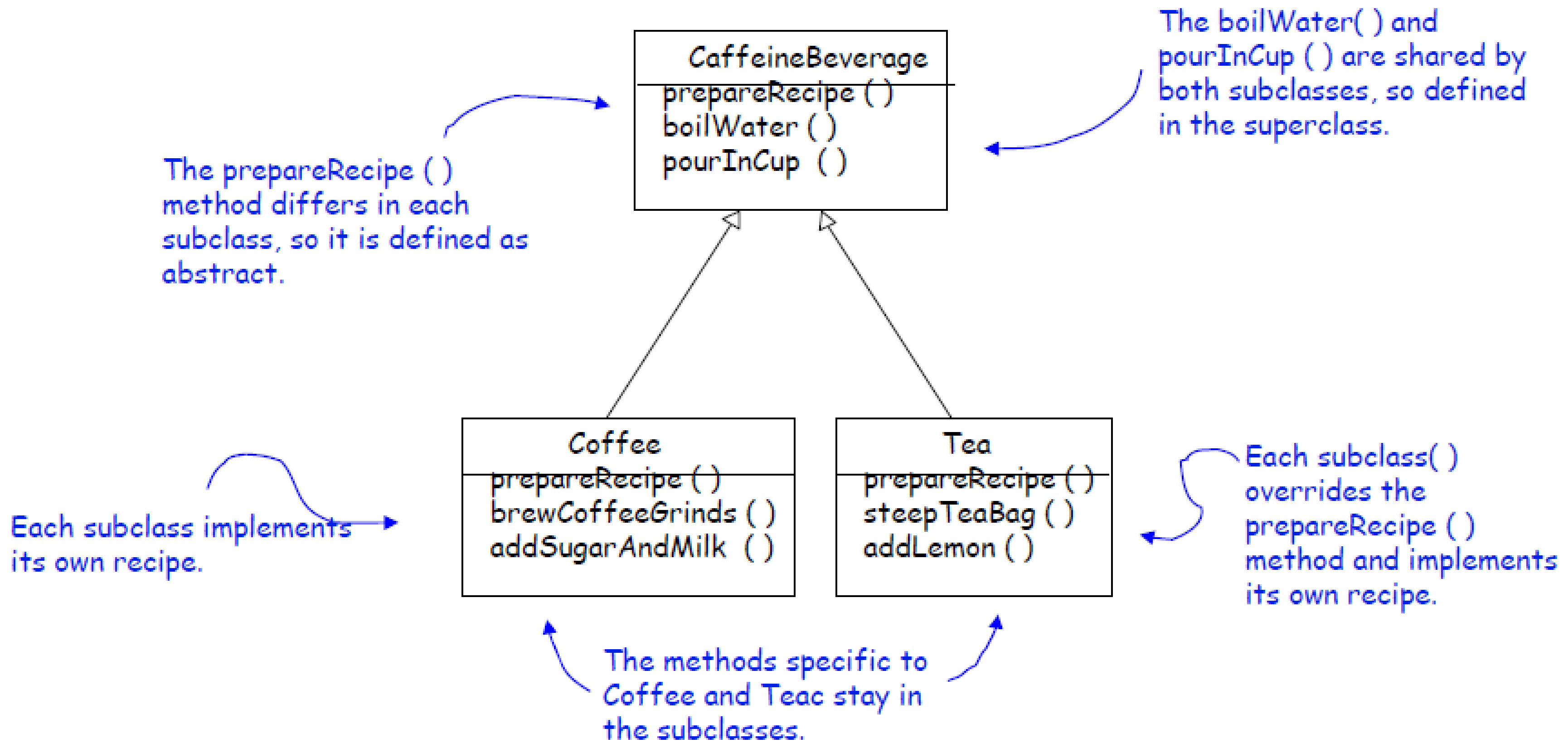
Very similar to the coffee - 2nd and 4th steps are different.

These methods are exactly the same

These methods are specialized to Tea

We have code duplication - that's a good sign that we need to clean up the design. We should abstract the commonality into a base class since coffee and tea are so similar, right??
-- Give a class diagram to show how you would redesign the classes.

Sir, may I abstract your Coffee, Tea?


CaffeineBeverage
prepareRecipe ( )
boilWater ( )
pourInCup ( )
Coffee
prepareRecipe ( )
brewCoffeeGrinds ( )
addSugarAndMilk ( )
Tea
prepareRecipe ( )
steepTeaBag ( )
addLemon ( )
The prepareRecipe ( ) method differs in each subclass, so it is defined as abstract.
The boilWater( ) and pourInCup ( ) are shared by both subclasses, so defined in the superclass.
Each subclass implements its own recipe.
Each subclass( ) overrides the prepareRecipe ( ) method and implements its own recipe.
The methods specific to Coffee and Teac stay in the subclasses.

Is this a good redesign? Are we overlooking some other commonality? What are other ways that Coffee and Tea are similar?

What else do they have in common?

Both the recipes follow the same algorithm:

(1) Boil some water

(2) Use hot water to extract the tea or coffee

(3) Pour the resulting beverage into a cup

(4) Add the appropriate condiments to the beverage.

These two are already abstracted into the base class.

These aren't abstracted but are the same, they just apply to different beverages.

Can we abstract prepareRecipe ( ) too? Yes...

Abstracting PrepareRecipe ( )

Provide a common interface for the different methods

- Problem : Coffee uses brewCoffeeGrinds ( ) and addSugarAndMilk () methods while Tea uses steepTeaBag ( ) and addLemon ( ) methods

- Steeping and brewing are pretty analogous -- so a common interface may be the ticket: brew ( ) and addCondiments ()

The New Java Classes….

Because Coffee and Tea handle these in different ways, they are going to have to be declared as abstract. Let the subclasses worry about that stuff!

```
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”);
      }
}
```

```
public class Tea extends CaffeineBeverage {
      public void brew ( ){
            System.out.println (“Steeping the Tes”);
      }
      public void addCondiments ( ) {
            System.out.println(“Adding Lemon”);
      }
}
```

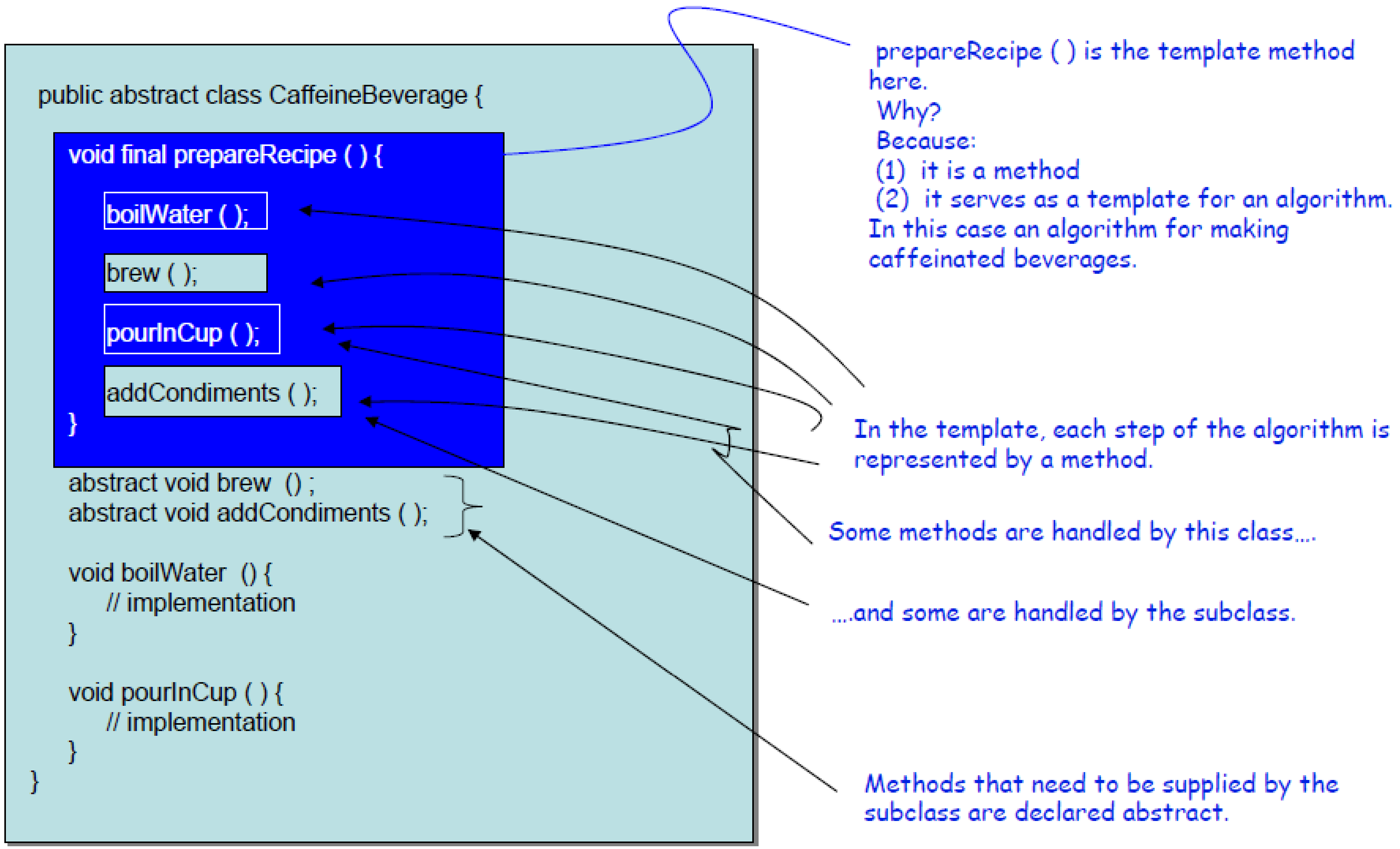
```
public class Coffee extends CaffeineBeverage {
      public void brew ( ) {
            System.out.println (“Dripping Coffee Thru the Filters”);
      }
      public void addCondiments ( ){
            System.out.println(“Adding Sugar and Milk”);
      }
}
```

What have we done?

- We have recognized that the two recipes are essentially the same, although some of the steps require different implementations.
  - So we've generalized the recipe and placed it in the base class.
  - We've made it so that some of the steps in the recipe rely on the subclass implementations.

Essentially - we have implemented the Template Method Pattern!

Meet the Template Method



```
public abstract class CaffeineBeverage {
    void final prepareRecipe ( ) {
        boilWater ( );
        brew ( );
        pourInCup ( );
        addCondiments ( );
    }
    abstract void brew  ( ) ;
    abstract void addCondiments ( );

    void boilWater  () {
        // implementation
    }

    void pourInCup ( ) {
        // implementation
    }
}
```

prepareRecipe ( ) is the template method here.
Why?
Because:
(1) it is a method
(2) it serves as a template for an algorithm.
In this case an algorithm for making caffeinated beverages.
In the template, each step of the algorithm is represented by a method.
Some methods are handled by this class....
....and some are handled by the subclass.
Methods that need to be supplied by the subclass are declared abstract.

The Template Method defines the steps of an algorithm and allows subclasses to provide the implementation of one or more steps.

Behind the scenes…..

```
 Tea myTea = new Tea ( );

myTea.prepareRecipe ( );
            boilWater ( );
            brew ( );
            pourInCup ( );
            addCondiments ( );
```

Polymorphism ensures that while the template controls everything, it still calls the right methods.

The Template Method

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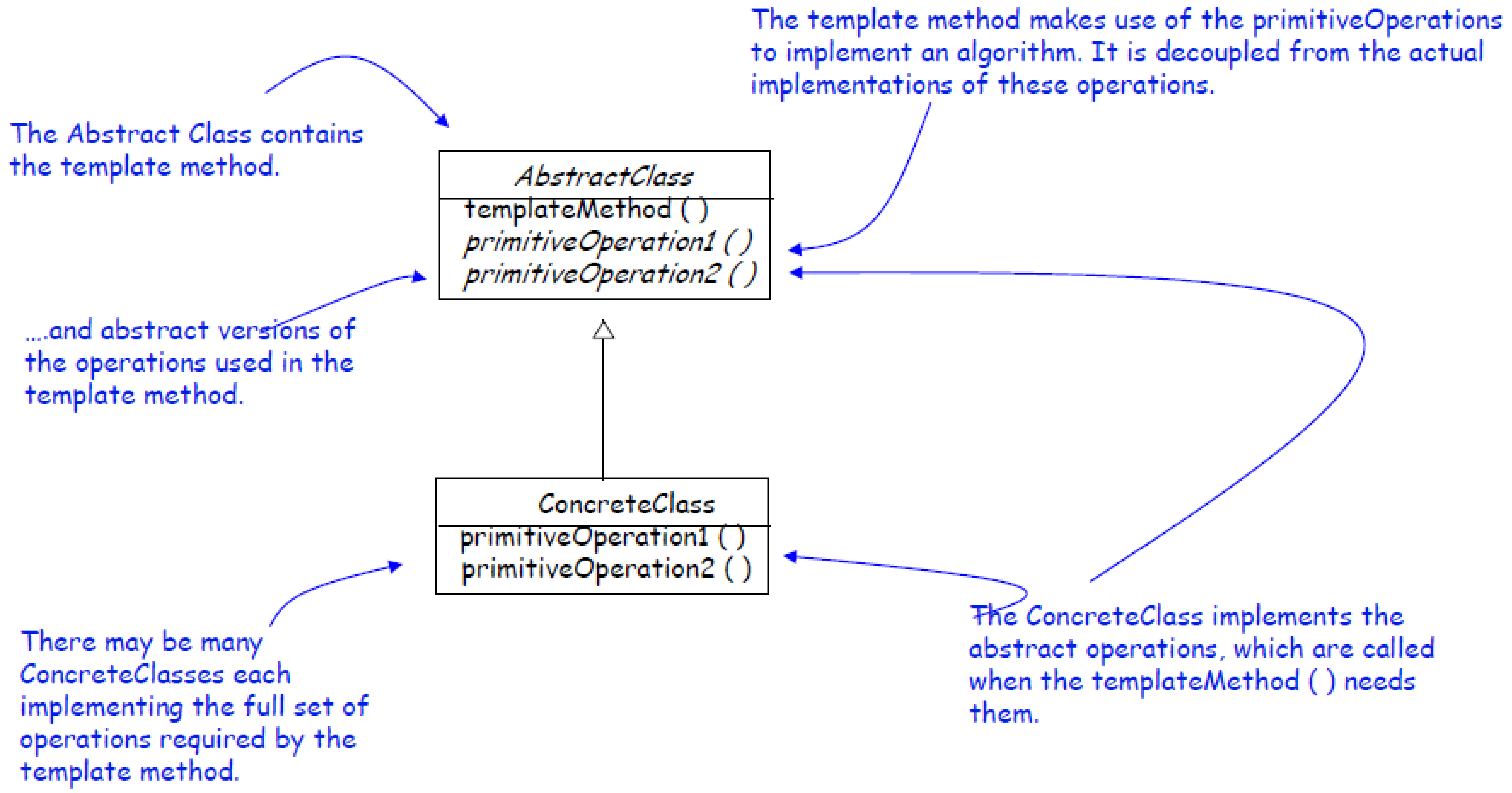
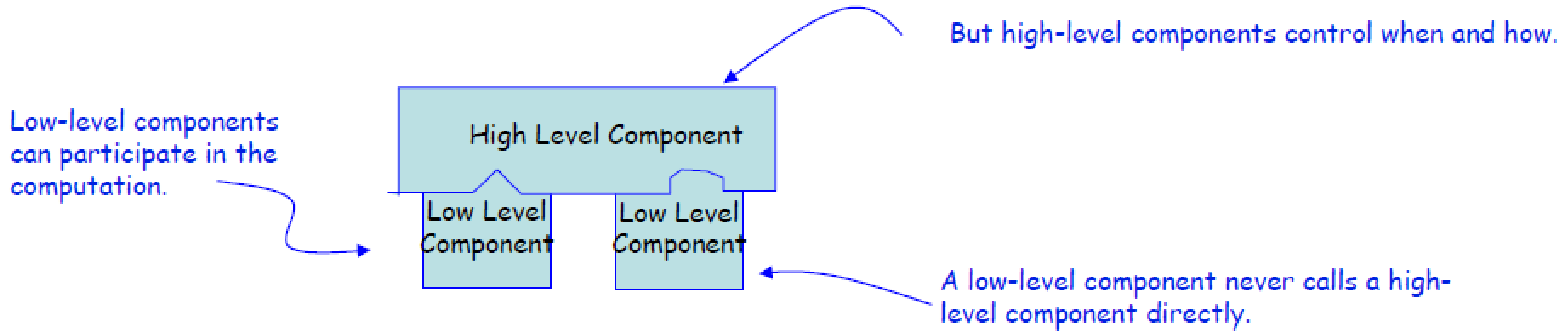

The template method makes use of the primitiveOperations to implement an algorithm. It is decoupled from the actual implementations of these operations.
The Abstract Class contains the template method.
AbstractClass
templateMethod ( )
primitiveOperation1 ( )
primitiveOperation2 ( )
....and abstract versions of the operations used in the template method.
ConcreteClass
primitiveOperation1 ( )
primitiveOperation2 ( )
There may be many ConcreteClasses each implementing the full set of operations required by the template method.
The ConcreteClass implements the abstract operations, which are called when the templateMethod ( ) needs them.

The Hollywood Principle

Don’t call us, we’ll call you!

With the Hollywood principle

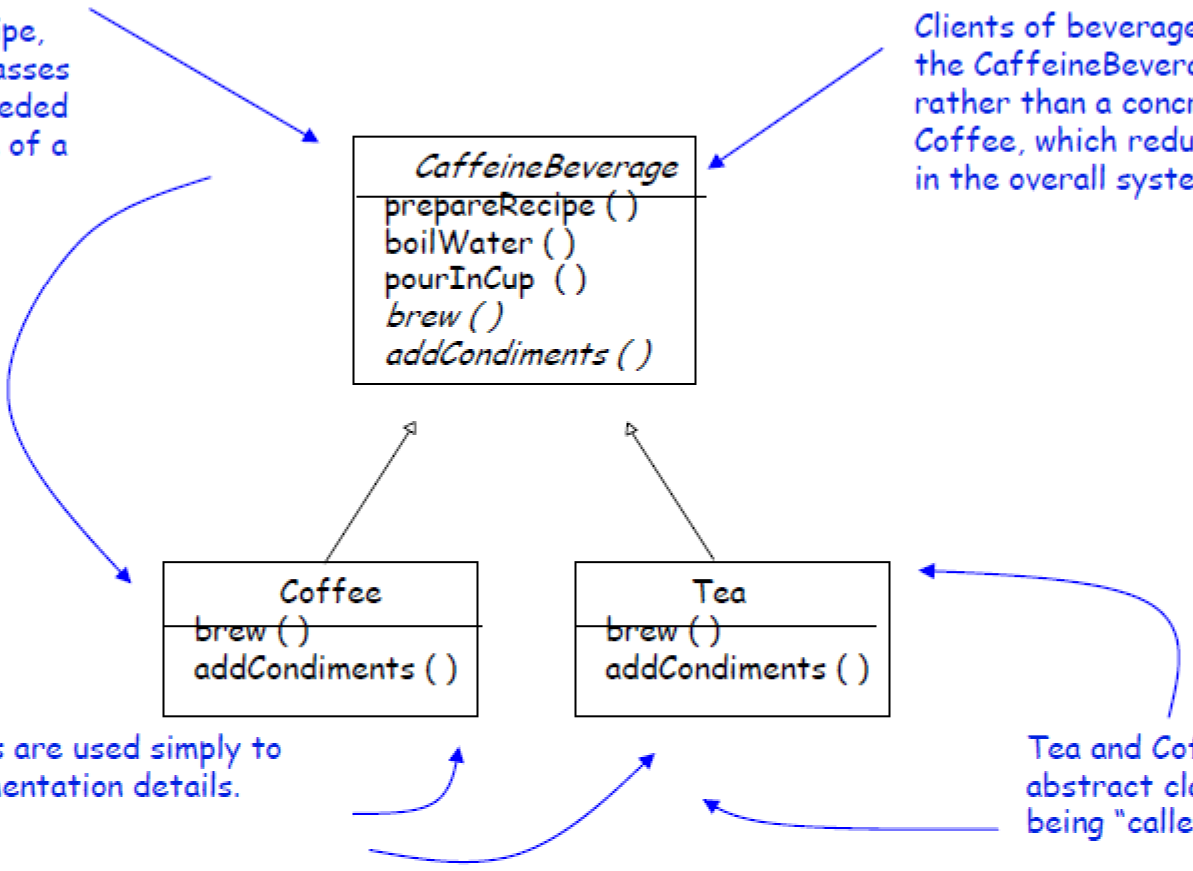
- We allow low level components to hook themselves into a system
- But high level components determine when they are needed and how.
- High level components give the low-level components a “don’t call us, we’ll call you” treatment.


But high-level components control when and how.
Low-level components can participate in the computation.
High Level Component
Low Level Component
Low Level Component
A low-level component never calls a high-level component directly.

The Hollywood Principle and the Template Method

CaffeineBeverage is our high-level component. It has control over the algorithm for the recipe, and calls on the subclasses only when they are needed for an implementation of a method.

Clients of beverages will depend on the CaffeineBeverage abstraction rather than a concrete Tea or Coffee, which reduces dependencies in the overall system.



The subclasses are used simply to provide implementation details.

Tea and Coffee never call the abstract class directly without being “called” first.

Template Method implementation in Java

- Give primitive and hook methods protected access
  - These methods are intended to be called by a template method, and not directly by clients
- Declare primitive methods as abstract in the superclass
  - Primitive methods **must** be implemented by subclasses
- Declare hook methods as non-abstract
  - Hook methods **may** optionally be overridden by subclasses
- Declare template methods as final
  - This prevents a subclass from overriding the method and interfering with it’s algorithm structure

```
abstract class Game{
    private int playersCount;
    abstract void initializeGame();
    abstract void makePlay(int player);
    abstract boolean endOfGame();
    abstract void printWinner();
    final void playOneGame(int playersCount){
            this.playersCount = playersCount;
            initializeGame();
            int j = 0;
            while( ! endOfGame() ){
                    makePlay( j );
                     j = (j + 1) % playersCount;
            }
            printWinner();
    } }
```

```
class Monopoly extends Game{
    /* Implementation of necessary concrete methods */
    void initializeGame(){ // ... }
    void makePlay(int player){ // ... }
    boolean endOfGame(){ // ... }
    void printWinner(){ // ... }
     /* Specific declarations for the Monopoly game. */
}
```

```
class Chess extends Game{
    /* Implementation of necessary concrete methods */
    void initializeGame(){ // ... }
    void makePlay(int player){ // ... }
    boolean endOfGame(){ // ... }
    void printWinner(){ // ... }
    /* Specific declarations for the Chess game. */
}
```