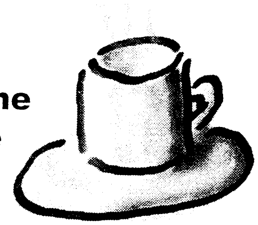
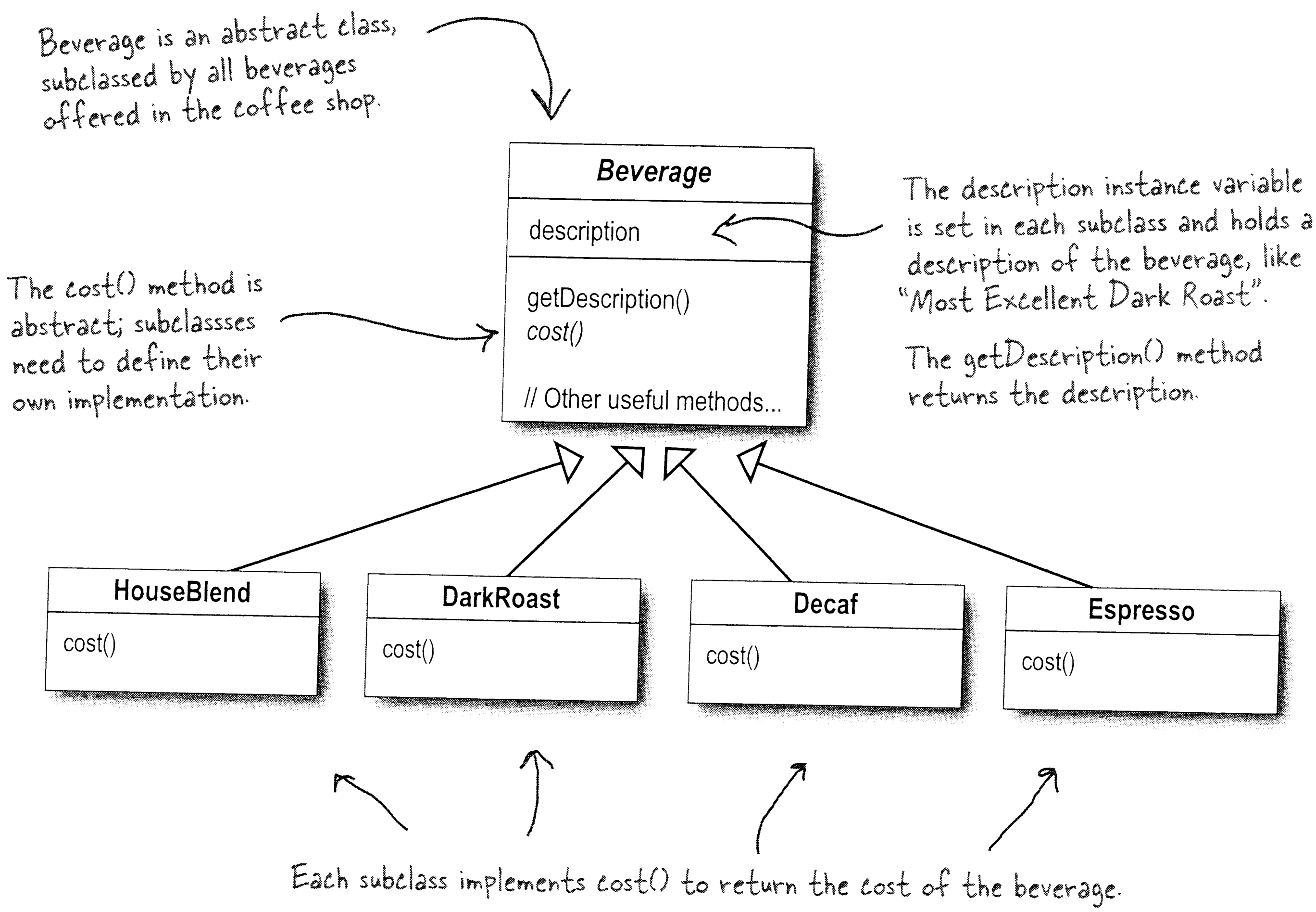
Welcome to Starbuzz Coffee



Starbuzz Coffee has made a name for itself as the fastest growing coffee shop around. If you've seen one on your local corner, look across the street; you'll see another one.

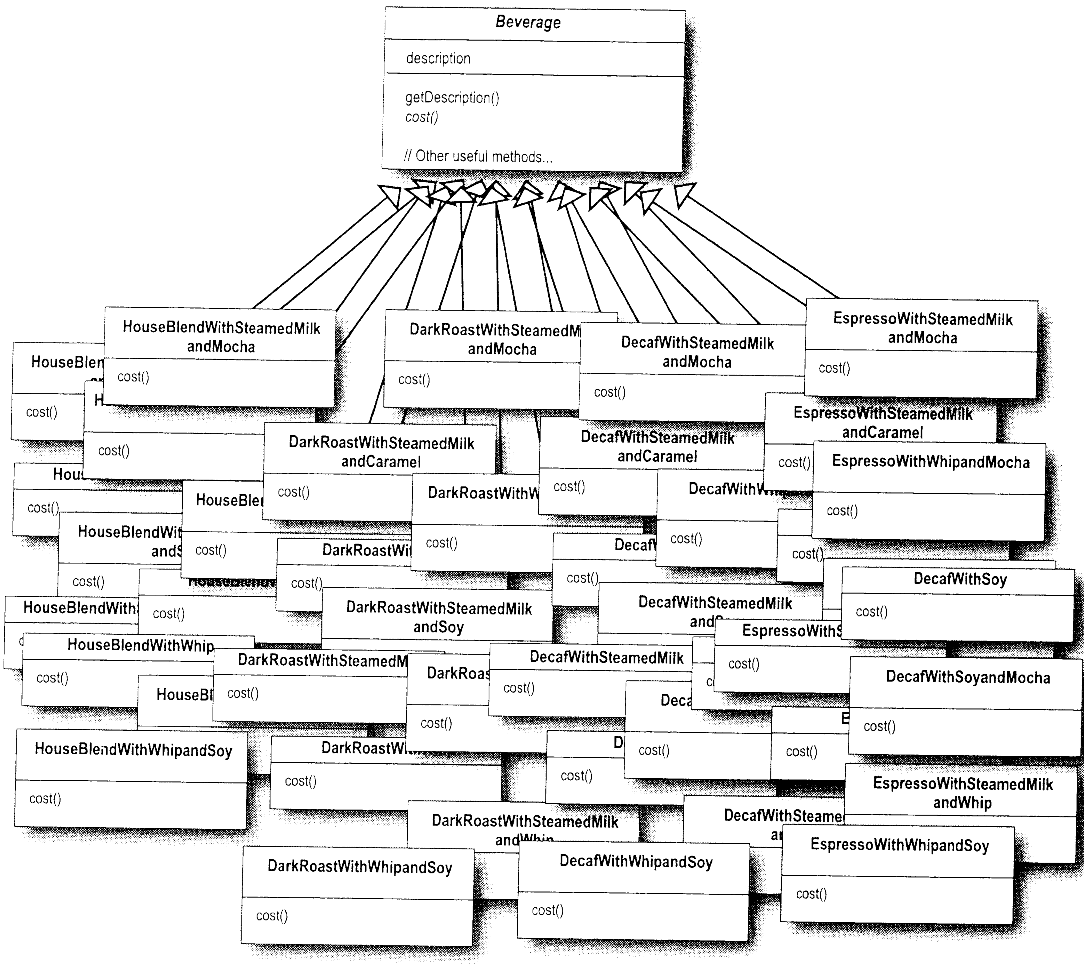
Because they've grown so quickly, they're scrambling to update their ordering systems to match their beverage offerings.

When they first went into business they designed their classes like this...



In addition to your coffee, you can also ask for several condiments like steamed milk, soy, and mocha (otherwise known as chocolate), and have it all topped off with whipped milk. Starbuzz charges a bit for each of these, so they really need to get them built into their order system.

Here's their first attempt...



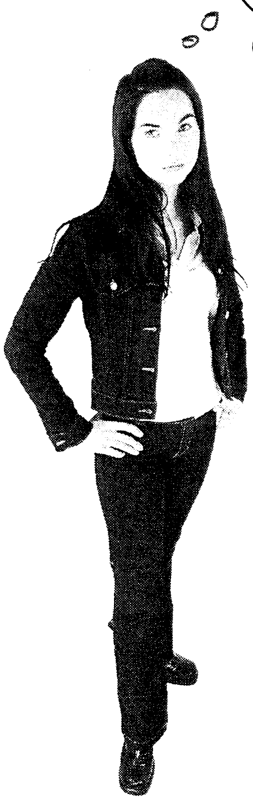
Each cost method computes the cost of the coffee along with the other condiments in the order.

BRAIN POWER

It's pretty obvious that Starbuzz has created a maintenance nightmare for themselves. What happens when the price of milk goes up? What do they do when they add a new caramel topping?

Thinking beyond the maintenance problem, which of the design principles that we've covered so far are they violating?

Hint: they're violating two of them in a big way!



This is stupid; why do we need all these classes? Can't we just use instance variables and inheritance in the superclass to keep track of the condiments?

Well, let's give it a try. Let's start with the Beverage base class and add instance variables to represent whether or not each beverage has milk, soy, mocha and whip...

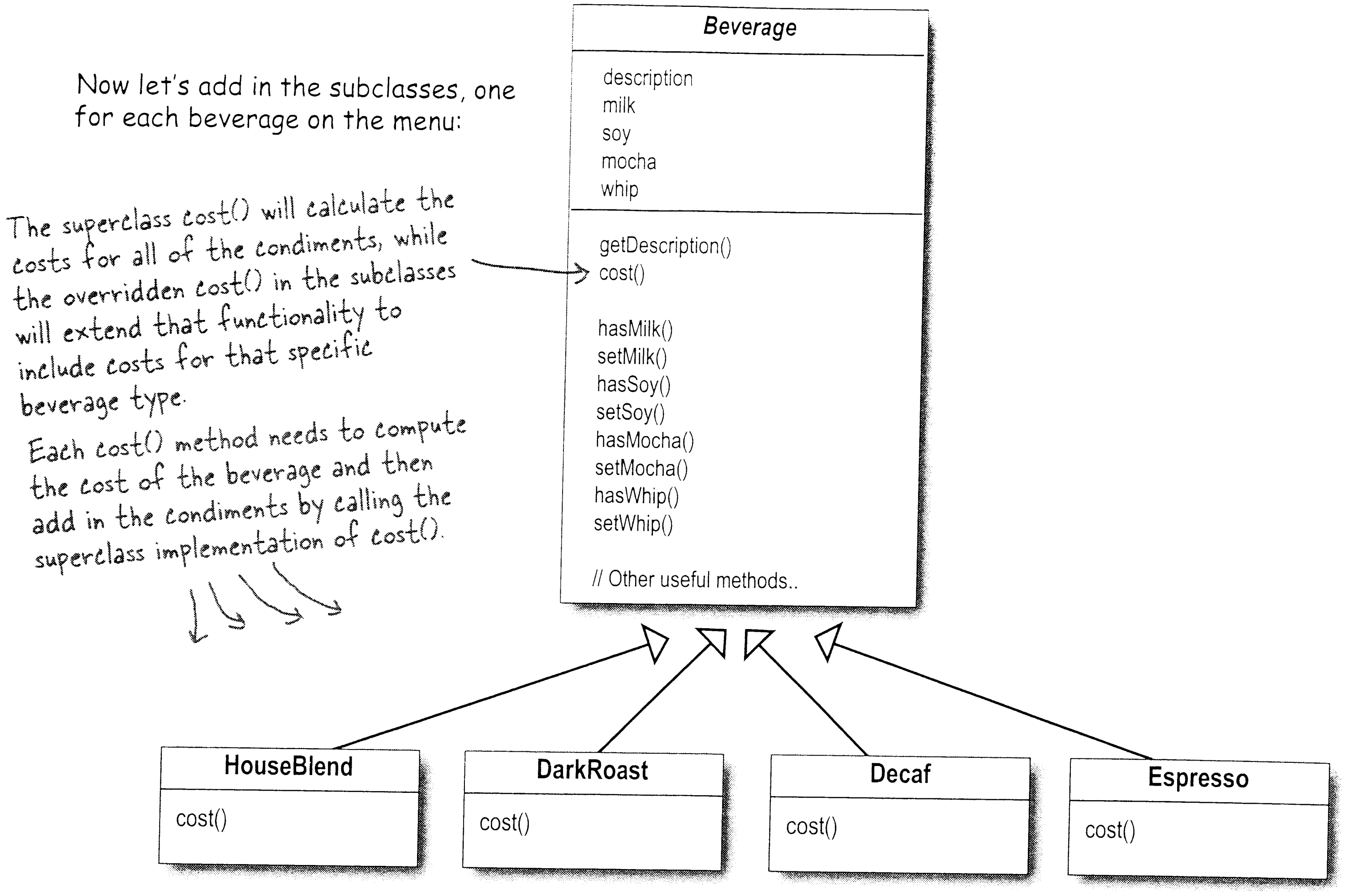
Beverage
description milk soy mocha whip
getDescription() cost() hasMilk() setMilk() hasSoy() setSoy() hasMocha() setMocha() hasWhip() setWhip() // Other useful methods..

New boolean values for each condiment.

Now we'll implement cost() in Beverage (instead o keeping it abstract), so that it can calculate th costs associated with the condiments for a part beverage instance. Subclasses will still override cost(), but they will also invoke the super versior that they can calculate the total cost of the b beverage plus the costs of the added condiments

These get and set the boolean values for the condiments.

Now let's add in the subclasses, one for each beverage on the menu:



Sharpen your pencil

Write the cost() methods for the following classes (pseudo-Java is okay):

```
public class Beverage {
   public double cost() {



   }
}
```

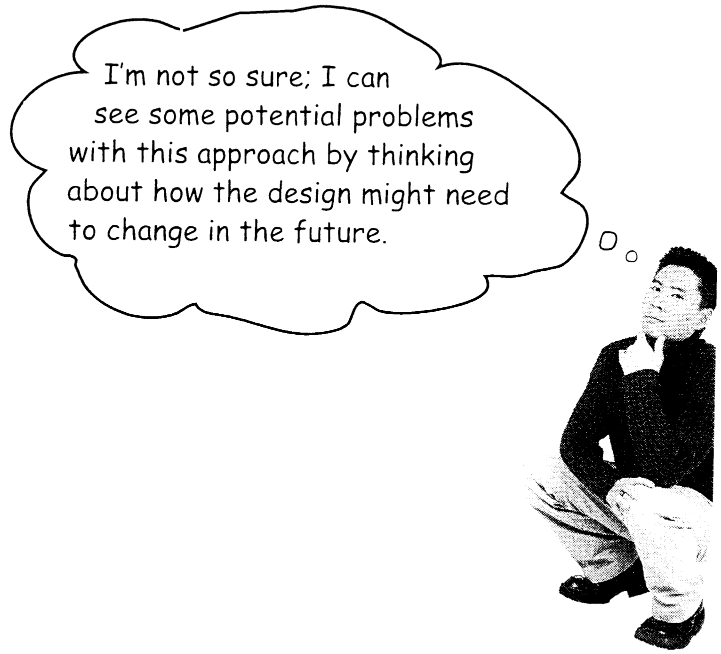
```
public class DarkRoast extends Beverage {

   public DarkRoast() {
      description = "Most Excellent Dark Roast";
   }

   public double cost() {



   }
}
```



Sharpen your pencil

What requirements or other factors might change that will impact this design?

Price changes for condiments will force us to alter existing code.

New condiments will force us to add new methods and alter the cost method in the superclass.

We may have new beverages. For some of these beverages (iced tea?), the condiments may not be appropriate, yet the Tea subclass will still inherit methods like hasWhip().

As we saw in Chapter 1, ! a very bad

What if a customer wants a double mocha?

Your turn:

Master and Student...

Master: *Grasshopper, it has been some time since our last meeting. Have you been deep in meditation on inheritance?*

Student: *Yes, Master. While inheritance is powerful, I have learned that it doesn't always lead to the most flexible or maintainable designs.*

Master: *Ah yes, you have made some progress. So, tell me my student, how then will you achieve reuse if not through inheritance?*

Student: *Master, I have learned there are ways of "inheriting" behavior at runtime through composition and delegation.*

Master: *Please, go on...*

Student: *When I inherit behavior by subclassing, that behavior is set statically at compile time. In addition, all subclasses must inherit the same behavior. If however, I can extend an object's behavior through composition, then I can do this dynamically at runtime.*

Master: *Very good, Grasshopper, you are beginning to see the power of composition.*

Student: *Yes, it is possible for me to add multiple new responsibilities to objects through this technique, including responsibilities that were not even thought of by the designer of the superclass. And, I don't have to touch their code!*

Master: *What have you learned about the effect of composition on maintaining your code?*

Student: *Well, that is what I was getting at. By dynamically composing objects, I can add new functionality by writing new code rather than altering existing code. Because I'm not changing existing code, the chances of introducing bugs or causing unintended side effects in pre-existing code are much reduced.*

Master: *Very good. Enough for today, Grasshopper. I would like for you to go and meditate further on this topic... Remember, code should be closed (to change) like the lotus flower in the evening, yet open (to extension) like the lotus flower in the morning.*

The Open-Closed Principle

Grasshopper is on to one of the most important design principles:

> ***Design Principle***
>
> *Classes should be open for extension, but closed for modification.*

Come on in; we're *open*. Feel free to extend our classes with any new behavior you like. If your needs or requirements change (and we know they will), just go ahead and make your own extensions.

Sorry, we're *closed*. That's right, we spent a lot of time getting this code correct and bug free, so we can't let you alter the existing code. It must remain closed to modification. If you don't like it, you can speak to the manager.

Our goal is to allow classes to be easily extended to incorporate new behavior without modifying existing code. What do we get if we accomplish this? Designs that are resilient to change and flexible enough to take on new functionality to meet changing requirements.

there are no Dumb Questions

Q: Open for extension and closed for modification? That sounds very contradictory. How can a design be both?

A: That's a very good question. It certainly sounds contradictory at first. After all, the less modifiable something is, the harder it is to extend, right?

As it turns out, though, there are some clever OO techniques for allowing systems to be extended, even if we can't change the underlying code. Think about the Observer Pattern (in Chapter 2)... by adding new Observers, we can extend the Subject at any time, without adding code to the Subject. You'll see quite a few more ways of extending behavior with other OO design techniques.

Q: Okay, I understand Observable, but how do I generally design something to be extensible, yet closed for modification?

A: Many of the patterns give us time tested designs that protect your code from being modified by supplying a means of extension. In this chapter you'll see a good example of using the Decorator pattern to follow the Open-Closed principle.

Q: How can I make every part of my design follow the Open-Closed Principle?

A: Usually, you can't. Making OO design flexible and open to extension without the modification of existing code takes time and effort. In general, we don't have the luxury of tying down every part of our designs (and it would probably be wasteful). Following the Open-Closed Principle usually introduces new levels of abstraction, which adds complexity to our code. You want to concentrate on those areas that are most likely to change in your designs and apply the principles there.

Q: How do I know which areas of change are more important?

A: That is partly a matter of experience in designing OO systems and also a matter of knowing the domain you are working in. Looking at other examples will help you learn to identify areas of change in your own designs.

While it may seem like a contradiction, there are techniques for allowing code to be extended without direct modification.

Be careful when choosing the areas of code that need to be extended; applying the Open-Closed Principle EVERYWHERE is wasteful, unnecessary, and can lead to complex, hard to understand code.

Meet the Decorator Pattern

Okay, we've seen that representing our beverage plus condiment pricing scheme with inheritance has not worked out very well – we get class explosions, rigid designs, or we add functionality to the base class that isn't appropriate for some of the subclasses.

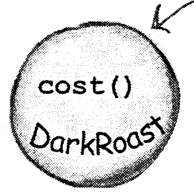
So, here's what we'll do instead: we'll start with a beverage and "decorate" it with the condiments at runtime. For example, if the customer wants a Dark Roast with Mocha and Whip, then we'll:

1. **Take a DarkRoast object**
2. **Decorate it with a Mocha object**
3. **Decorate it with a Whip object**
4. **Call the cost() method and rely on delegation to add on the condiment costs**

Okay, but how do you "decorate" an object, and how does delegation come into this? A hint: think of decorator objects as "wrappers." Let's see how this works...

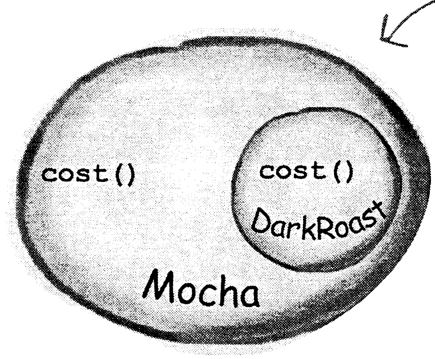
Constructing a drink order with Decorators

1 We start with our DarkRoast object.



Remember that DarkRoast inherits from Beverage and has a cost() method that computes the cost of the drink.

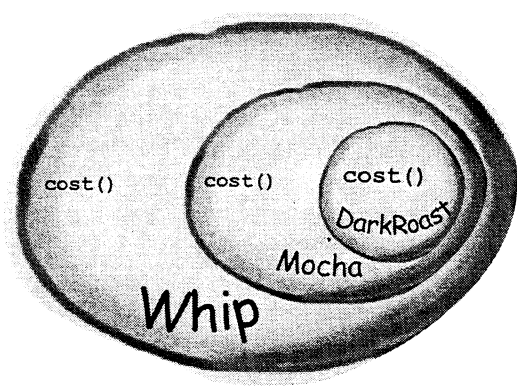
2 The customer wants Mocha, so we create a Mocha object and wrap it around the DarkRoast.



The Mocha object is a decorator. Its type mirrors the object it is decorating, in this case, a Beverage. (By "mirror", we mean it is the same type..)

So, Mocha has a cost() method too, and through polymorphism we can treat any Beverage wrapped in Mocha as a Beverage, too (because Mocha is a subtype of Beverage).

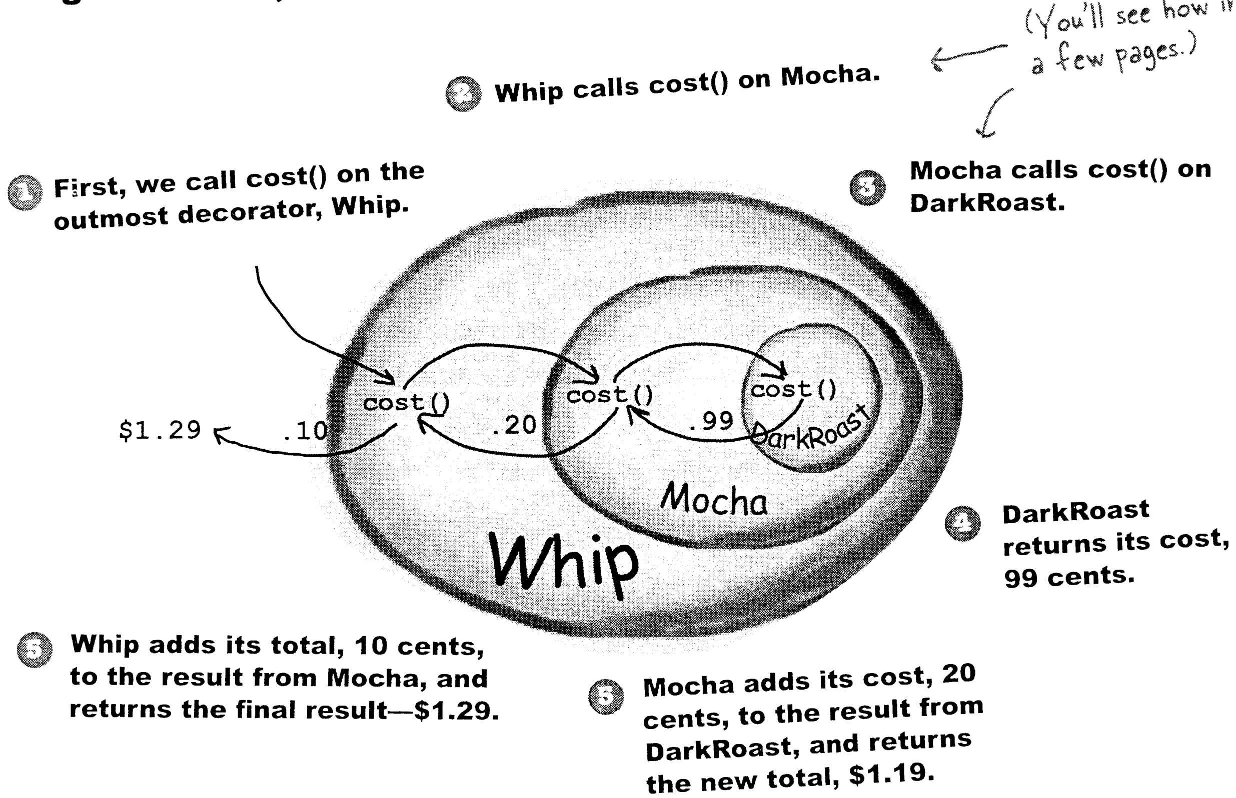
3 The customer also wants Whip, so we create a Whip decorator and wrap Mocha with it.



Whip is a decorator, so it also mirrors DarkRoast's type and includes a cost() method.

So, a DarkRoast wrapped in Mocha and Whip is still a Beverage and we can do anything with it we can do with a DarkRoast, including call its cost() method.

4 Now it's time to compute the cost for the customer. We do this by calling cost() on the outermost decorator, Whip, and Whip is going to delegate computing the cost to the objects it decorates. Once it gets a cost, it will add on the cost of the Whip.



Okay, here's what we know so far...

- Decorators have the same supertype as the objects they decorate.
- You can use one or more decorators to wrap an object.
- Given that the decorator has the same supertype as the object it decorates, we can pass around a decorated object in place of the original (wrapped) object.
- The decorator adds its own behavior either before and/or after delegating to the object it decorates to do the rest of the job. Key Point!
- Objects can be decorated at any time, so we can decorate objects dynamically at runtime with as many decorators as we like.

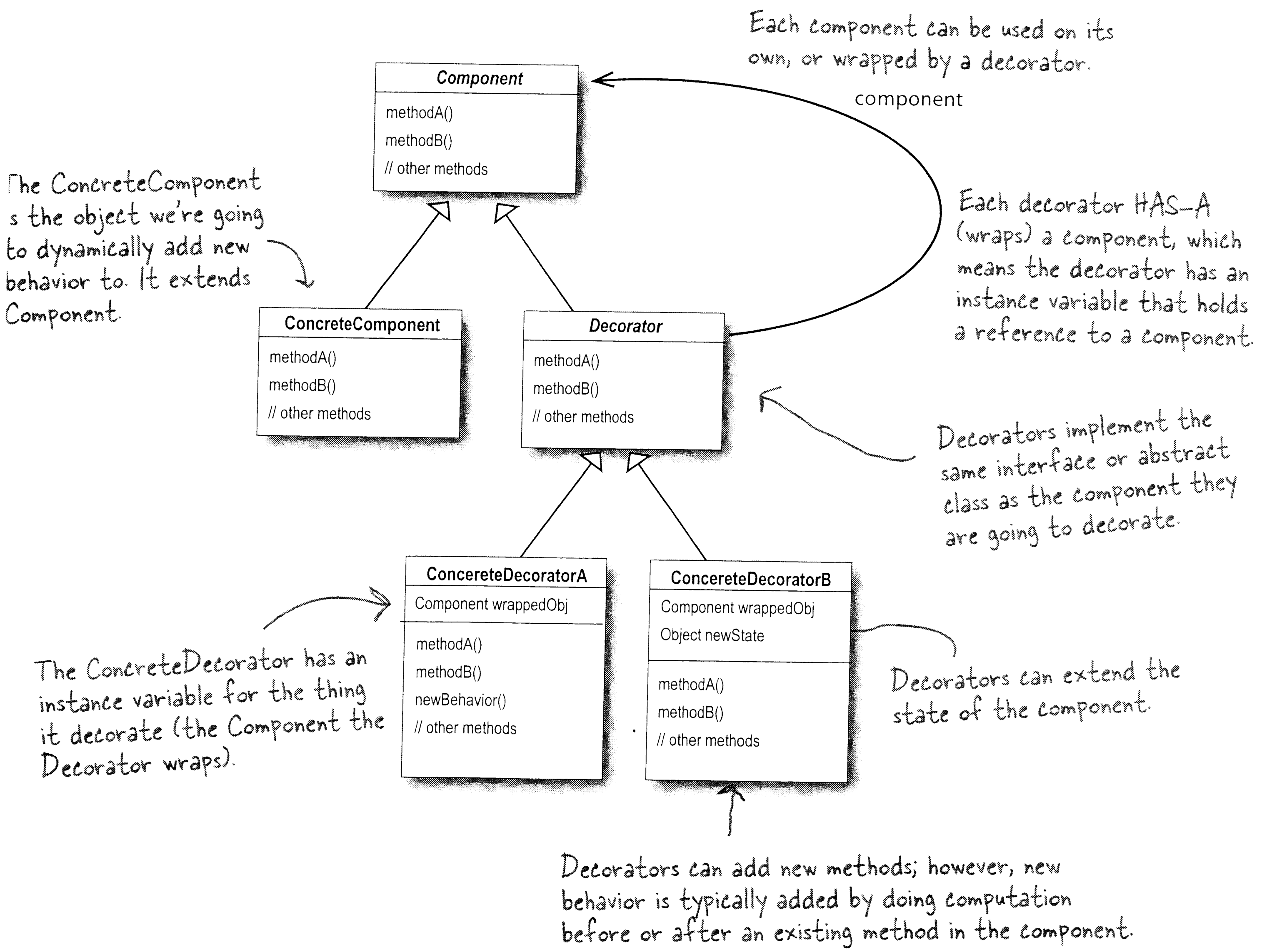
Now let's see how this all really works by looking at the Decorator Pattern definition and writing some code.

'he Decorator Pattern defined

.et's first take a look at the Decorator Pattern description:

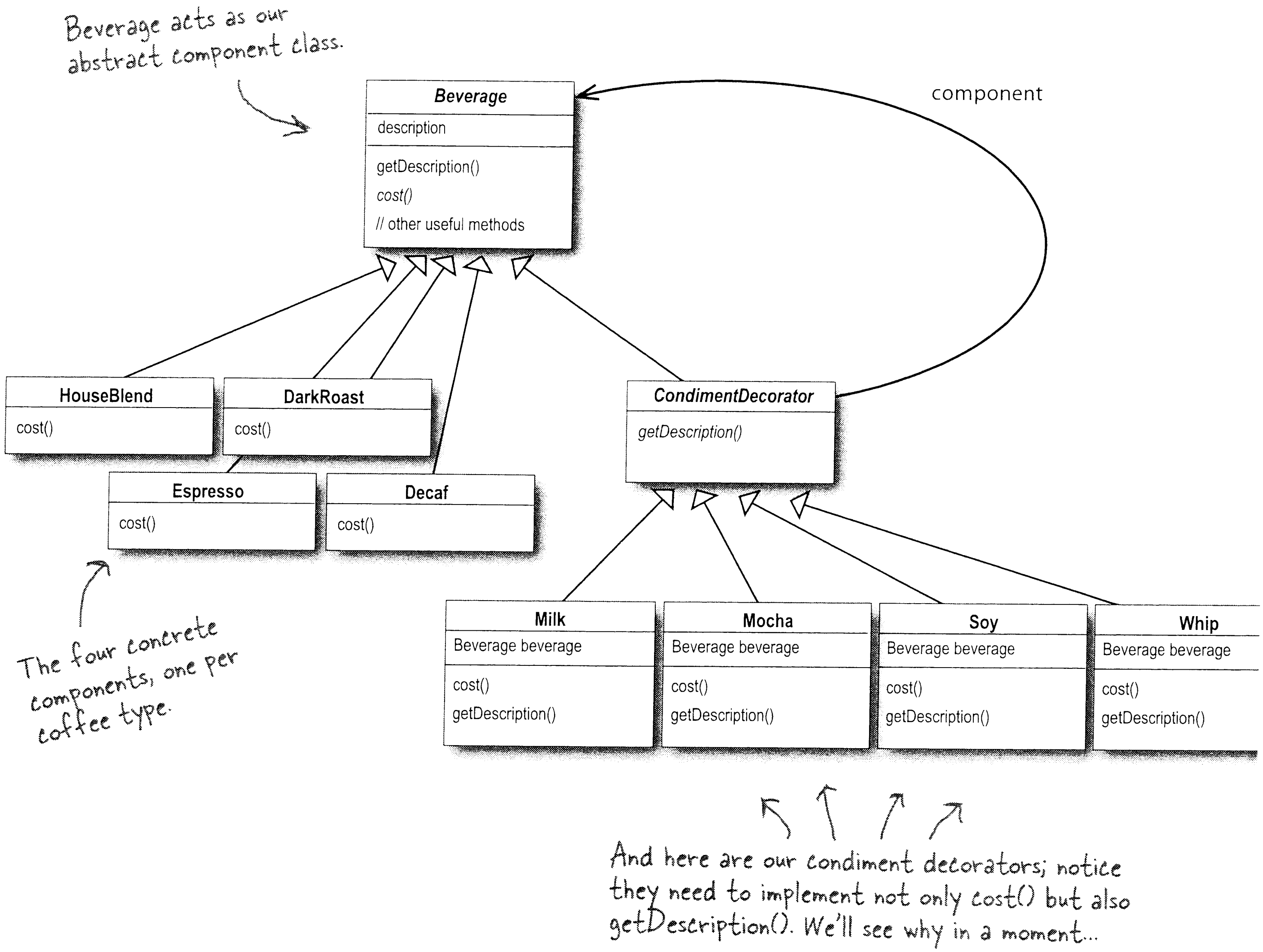
> **The Decorator Pattern** attaches additional responsibilities to an object dynamically. Decorators provide a flexible alternative to subclassing for extending functionality.

Vhile that describes the *role* of the Decorator Pattern, it doesn't give us a lot f insight into how we'd *apply* the pattern to our own implementation. Let's ake a look at the class diagram, which is a little more revealing (on the next 'age we'll look at the same structure applied to the beverage problem).



Decorating our Beverages

Okay, let's work our Starbuzz beverages into this framework...

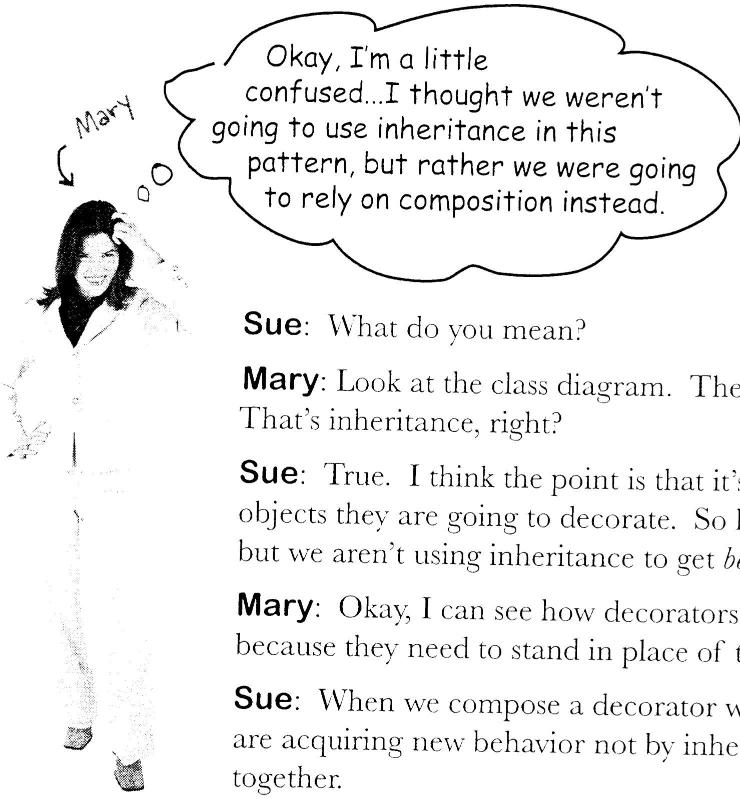


BRAIN POWER

Before going further, think about how you'd implement the cost() method of the coffees and the condiments. Also think about how you'd implement the getDescription() method of the condiments.

Cubicle Conversation

Some confusion over Inheritance versus Composition



Sue: What do you mean?

Mary: Look at the class diagram. The CondimentDecorator is extending the Beverage class. That's inheritance, right?

Sue: True. I think the point is that it's vital that the decorators have the same type as the objects they are going to decorate. So here we're using inheritance to achieve the *type matching*, but we aren't using inheritance to get *behavior*.

Mary: Okay, I can see how decorators need the same "interface" as the components they wrap because they need to stand in place of the component. But where does the behavior come in?

Sue: When we compose a decorator with a component, we are adding new behavior. We are acquiring new behavior not by inheriting it from a superclass, but by composing objects together.

Mary: Okay, so we're subclassing the abstract class Beverage in order to have the correct type, not to inherit its behavior. The behavior comes in through the composition of decorators with the base components as well as other decorators.

Sue: That's right.

Mary: Ooooh, I see. And because we are using object composition, we get a whole lot more flexibility about how to mix and match condiments and beverages. Very smooth.

Sue: Yes, if we rely on inheritance, then our behavior can only be determined statically at compile time. In other words, we get only whatever behavior the superclass gives us or that we override. With composition, we can mix and match decorators any way we like... *at runtime.*

Mary: And as I understand it, we can implement new decorators at any time to add new behavior. If we relied on inheritance, we'd have to go in and change existing code any time we wanted new behavior.

Sue: Exactly.

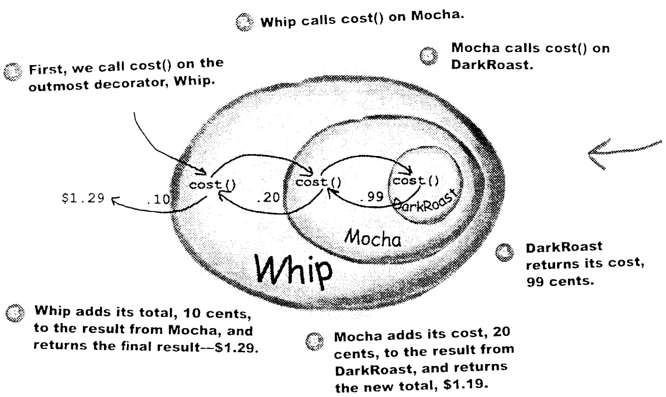
Mary: I just have one more question. If all we need to inherit is the type of the component, how come we didn't use an interface instead of an abstract class for the Beverage class?

Sue: Well, remember, when we got this code, Starbuzz already *had* an abstract Beverage class. Traditionally the Decorator Pattern does specify an abstract component, but in Java, obviously, we could use an interface. But we always try to avoid altering existing code, so don't "fix" it if the abstract class will work just fine.

New barista training

Make a picture for what happens when the order is for a "double mocha soy latte with whip" beverage. Use the menu to get the correct prices, and draw your picture using the same format we used earlier (from a few pages back):

Okay, I need for you to make me a *double* mocha, soy latte with whip.



This picture was for a "dark roast mocha whip" beverage.

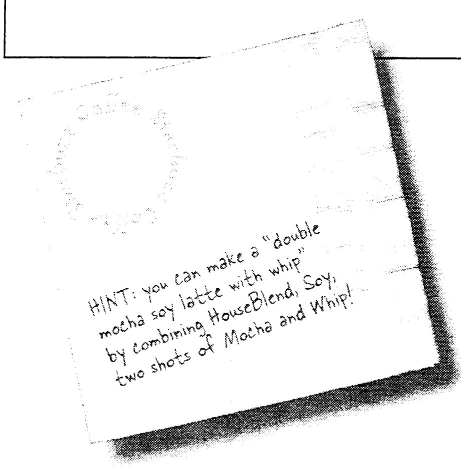
Sharpen your pencil

Draw your picture here.

Starbuzz Coffee

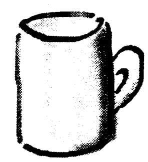
Coffees	
House Blend	.8
Dark Roast	.9
Decaf	1.0
Espresso	1.9

Condiments	
Steamed Milk	.10
Mocha	.20
Soy	.15
Whip	.10



Writing the Starbuzz code

It's time to whip this design into some real code.



Let's start with the Beverage class, which doesn't need to change from Starbuzz's original design. Let's take a look:

```
public abstract class Beverage {
    String description = "Unknown Beverage";

    public String getDescription() {
        return description;
    }

    public abstract double cost();
}
```

Beverage is an abstract class with the two methods getDescription() and cost().

getDescription is already implemented for us, but we need to implement cost() in the subclasses.

Beverage is simple enough. Let's implement the abstract class for the Condiments (Decorator) as well:

First, we need to be interchangeable with a Beverage, so we extend the Beverage class.

```
public abstract class CondimentDecorator extends Beverage {
    public abstract String getDescription();
}
```

We're also going to require that the condiment decorators all reimplement the getDescription() method. Again, we'll see why in a sec...

Coding beverages

Now that we've got our base classes out of the way, let's implement some beverages. We'll start with Espresso. Remember, we need to set a description for the specific beverage and also implement the cost() method.

First we extend the Beverage class, since this is a beverage.

```
public class Espresso extends Beverage {

    public Espresso() {
        description = "Espresso";
    }

    public double cost() {
        return 1.99;
    }
}
```

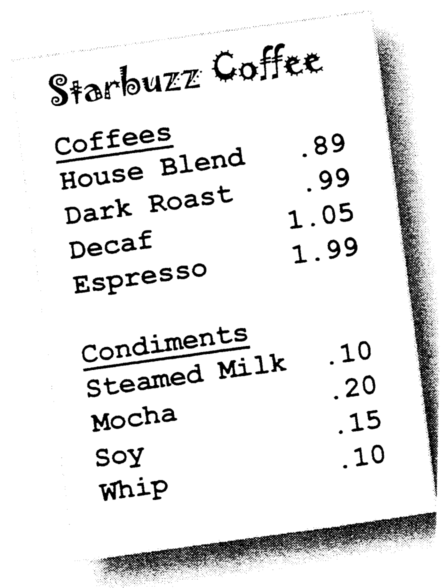
To take care of the description, we set this in the constructor for the class. Remember the description instanc variable is inherited from Beverage.

Finally, we need to compute the cost of an Espresso. We don't need to worry about adding in condiments in this class, we just need to return the price of an Espresso: $1.99.

```
public class HouseBlend extends Beverage {
    public HouseBlend() {
        description = "House Blend Coffee";
    }

    public double cost() {
        return .89;
    }
}
```

Okay, here's another Beverage. All we do is set the appropriate description, "House Blend Coffee," and then return the correct cost: 89¢.



You can create the other two Beverage classses (DarkRoast and Decaf) in exactly the same way.

Coding condiments

If you look back at the Decorator Pattern class diagram, you'll see we've now written our abstract component (Beverage), we have our concrete components (HouseBlend), and we have our abstract decorator (CondimentDecorator). Now it's time to implement the concrete decorators. Here's Mocha:

Mocha is a decorator, so we extend CondimentDecorator.

Remember, CondimentDecorator extends Beverage.

```
public class Mocha extends CondimentDecorator {
    Beverage beverage;

    public Mocha(Beverage beverage) {
        this.beverage = beverage;
    }

    public String getDescription() {
        return beverage.getDescription() + ", Mocha";
    }

    public double cost() {
        return .20 + beverage.cost();
    }
}
```

We're going to instantiate Mocha with a reference to a Beverage using:

(1) An instance variable to hold the beverage we are wrapping.

(2) A way to set this instance variable to the object we are wrapping. Here, we're going to to pass the beverage we're wrapping to the decorator's constructor.

We want our description to not only include the beverage – say "Dark Roast" – but also to include each item decorating the beverage, for instance, "Dark Roast, Mocha". So we first delegate to the object we are decorating to get its description, then append ", Mocha" to that description.

Now we need to compute the cost of our beverage with Mocha. First, we delegate the call to the object we're decorating, so that it can compute the cost; then, we add the cost of Mocha to the result.

On the next page we'll actually instantiate the beverage and wrap it with all its condiments (decorators), but first...

Sharpen your pencil

Write and compile the code for the other Soy and Whip condiments. You'll need them to finish and test the application.

Serving some coffees

Congratulations. It's time to sit back, order a few coffees and marvel at the flexible design you created with the Decorator Pattern.

Here's some test code* to make orders:

```
public class StarbuzzCoffee {

    public static void main(String args[]) {
        Beverage beverage = new Espresso();
        System.out.println(beverage.getDescription()
                + " $" + beverage.cost());

        Beverage beverage2 = new DarkRoast();
        beverage2 = new Mocha(beverage2);
        beverage2 = new Mocha(beverage2);
        beverage2 = new Whip(beverage2);
        System.out.println(beverage2.getDescription()
                + " $" + beverage2.cost());

        Beverage beverage3 = new HouseBlend();
        beverage3 = new Soy(beverage3);
        beverage3 = new Mocha(beverage3);
        beverage3 = new Whip(beverage3);
        System.out.println(beverage3.getDescription()
                + " $" + beverage3.cost());
    }
}
```

Order up an espresso, no condiments and print its description and cost.

Make a DarkRoast object.

Wrap it with a Mocha.

Wrap it in a second Mocha.

Wrap it in a Whip.

Finally, give us a HouseBlend with Soy, Mocha, and Whip.

* We're going to see a much better way of creating decorated objects when we cover the Factory Pattern (and the Builder Pattern, which is covered in the appendix).

Now, let's get those orders in:

```
File Edit Window Help CloudsInMyCoffee
% java StarbuzzCoffee
Espresso $1.99
Dark Roast Coffee, Mocha, Mocha, Whip $1.49
House Blend Coffee, Soy, Mocha, Whip $1.34
%
```