



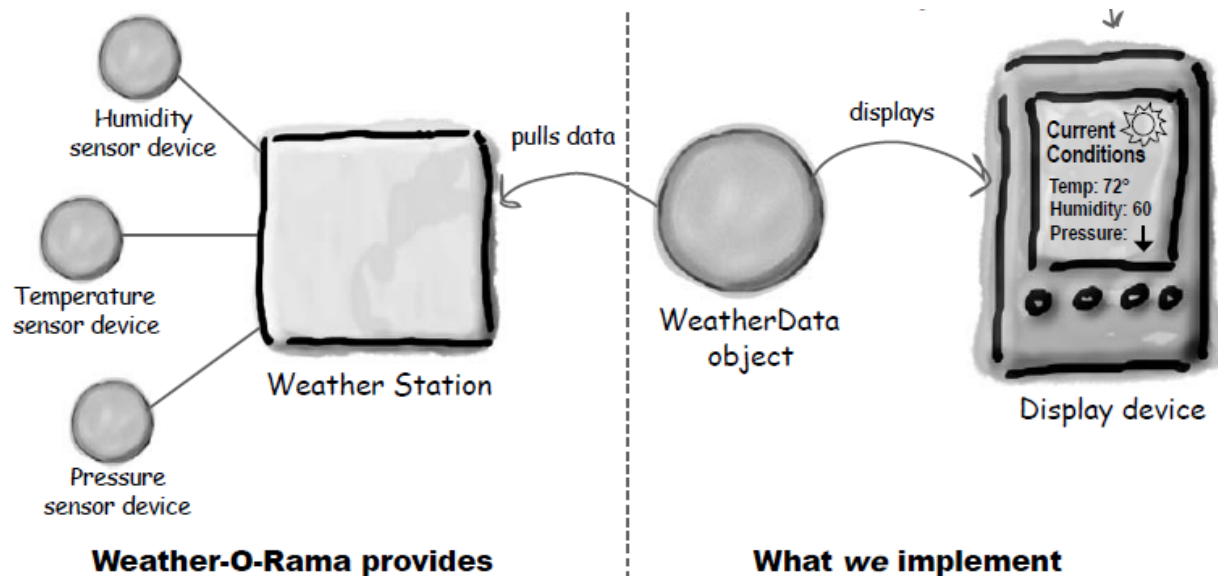
# Design Patterns

## Week 5: Observer and Decorator

Some slides are adapted from Jon Simon's ([jonathan\\_simon@yahoo.com](mailto:jonathan_simon@yahoo.com))

# Observer Pattern

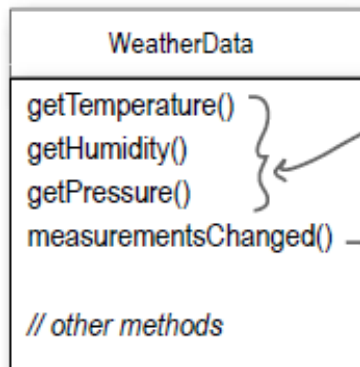
## ■ Weather Monitoring Application



# Weather Monitoring Application

- Weather Station which monitors humidity, temperature, and pressure.
- There are three different displays for showing the information from the Weather Station
  - Current Conditions
  - Weather Stats
  - Forecast
- Goal:
  - Changes in the Weather Station must update all three displays.
  - *In addition, need capability to add additional displays in the future.*

# WeatherData Class



These three methods return the most recent weather measurements for temperature, humidity and barometric pressure respectively.

We don't care HOW these variables are set; the WeatherData object knows how to get updated info from the Weather Station.

The developers of the WeatherData object left us a clue about what we need to add...

```
/*
 * This method gets called
 * whenever the weather measurements
 * have been updated
 */
public void measurementsChanged() {
    // Your code goes here
}
```

# WeatherData Class Implementation

```
public class WeatherData {  
  
    // instance variable declarations  
  
    public void measurementsChanged() {  
  
        float temp = getTemperature();  
        float humidity = getHumidity();  
        float pressure = getPressure();  
  
        currentConditionsDisplay.update(temp, humidity, pressure);  
        statisticsDisplay.update(temp, humidity, pressure);  
        forecastDisplay.update(temp, humidity, pressure);  
    }  
  
    // other WeatherData methods here  
}
```

Grab the most recent measurements by calling the WeatherData's getter methods (already implemented).

Now update the displays...

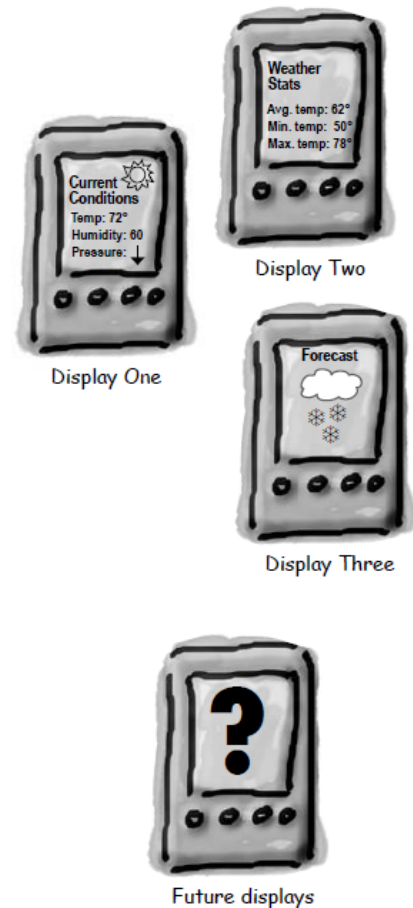
Call each display element to update its display, passing it the most recent measurements.

# What's Wrong with the Implementation

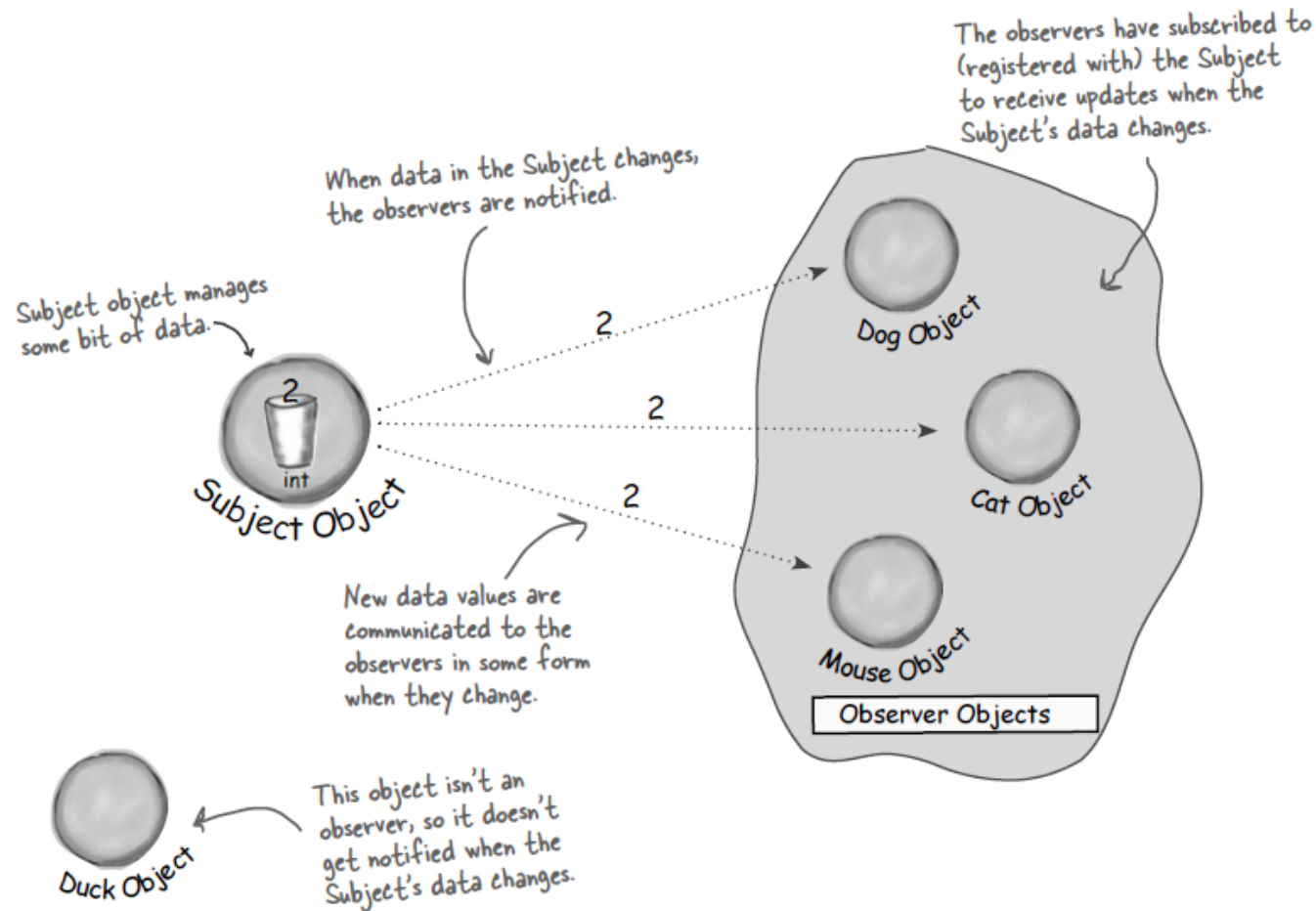
```
public void measurementsChanged() {  
  
    float temp = getTemperature();  
    float humidity = getHumidity();  
    float pressure = getPressure();  
  
    currentConditionsDisplay.update(temp, humidity, pressure);  
    statisticsDisplay.update(temp, humidity, pressure);  
    forecastDisplay.update(temp, humidity, pressure);  
}
```

By coding to concrete implementations we have no way to add or remove other display elements without making changes to the program.

At least we seem to be using a common interface to talk to the display elements... they all have an `update()` method takes the temp, humidity, and pressure values.



# Observer Pattern (Publishers + Subscribers)



# Definitions of Observer Pattern

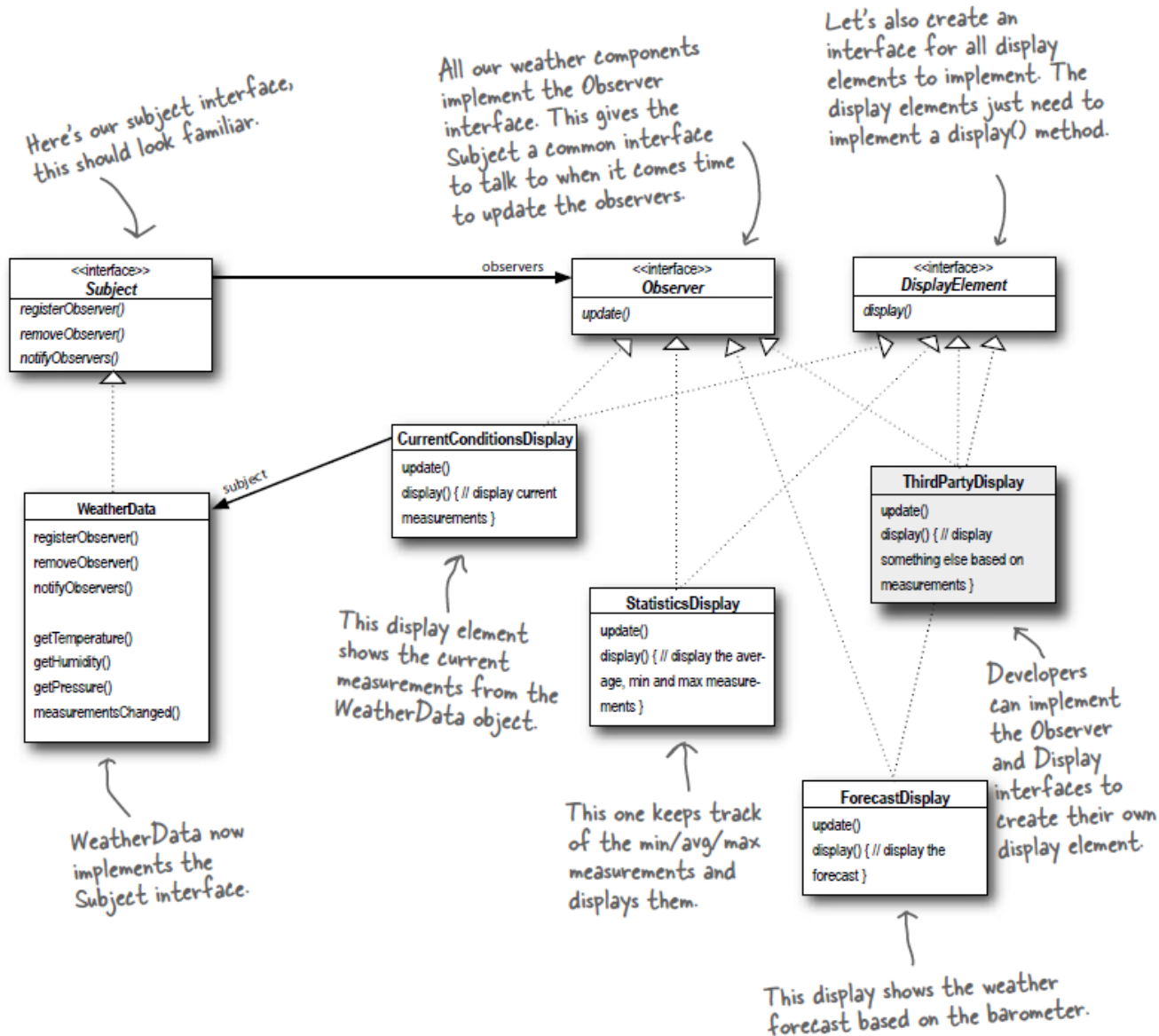
## ■ Subject

- Sends a notification message to one or many observers when there is a change in state.
- Along with the message, provides information on the state that has changed.

## ■ Observers – The objects that want to be notified about changes in the Subject's state



# Designing the Weather Station



# Implementing the Weather Station

```
public interface Subject {  
    public void registerObserver(Observer o);  
    public void removeObserver(Observer o);  
    public void notifyObservers();  
}
```

Both of these methods take an Observer as an argument; that is, the Observer to be registered or removed.

This method is called to notify all observers when the Subject's state has changed.

```
public interface Observer {  
    public void update(float temp, float humidity, float pressure);  
}
```

These are the state values the Observers get from the Subject when a weather measurement changes

The Observer interface is implemented by all observers, so they all have to implement the update() method. Here we're following Mary and Sue's lead and passing the measurements to the observers.

```
public interface DisplayElement {  
    public void display();  
}
```

The DisplayElement interface just includes one method, display(), that we will call when the display element needs to be displayed.

# Implementing the Weather Station

```
public class WeatherData implements Subject {  
    private ArrayList observers;  
    private float temperature;  
    private float humidity;  
    private float pressure;  
  
    public WeatherData() {  
        observers = new ArrayList();  
    }  
  
    public void registerObserver(Observer o) {  
        observers.add(o);  
    }  
  
    public void removeObserver(Observer o) {  
        int i = observers.indexOf(o);  
        if (i >= 0) {  
            observers.remove(i);  
        }  
    }  
  
    public void notifyObservers() {  
        for (int i = 0; i < observers.size(); i++) {  
            Observer observer = (Observer)observers.get(i);  
            observer.update(temperature, humidity, pressure);  
        }  
    }  
}
```

WeatherData now implements the Subject interface.

We've added an ArrayList to hold the Observers, and we create it in the constructor.

When an observer registers, we just add it to the end of the list.

Likewise, when an observer wants to un-register, we just take it off the list.

Here's the fun part; this is where we tell all the observers about the state. Because they are all Observers, we know they all implement update(), so we know how to notify them.

Here we implement the Subject Interface.

# Implementing the Weather Station

```
public void measurementsChanged() {  
    notifyObservers();  
}  
  
public void setMeasurements(float temperature, float humidity, float pressure) {  
    this.temperature = temperature;  
    this.humidity = humidity;  
    this.pressure = pressure;  
    measurementsChanged();  
}  
  
// other WeatherData methods here  
}
```

← We notify the Observers when we get updated measurements from the Weather Station.

← Okay, while we wanted to ship a nice little weather station with each book, the publisher wouldn't go for it. So, rather than reading actual weather data off a device, we're going to use this method to test our display elements. Or, for fun, you could write code to grab measurements off the web.

# Implementing the Weather Station

```
public class CurrentConditionsDisplay implements Observer, DisplayElement {
    private float temperature;
    private float humidity;
    private Subject weatherData;

    public CurrentConditionsDisplay(Subject weatherData) {
        this.weatherData = weatherData;
        weatherData.registerObserver(this);
    }

    public void update(float temperature, float humidity, float pressure) {
        this.temperature = temperature;
        this.humidity = humidity;
        display();
    }

    public void display() {
        System.out.println("Current conditions: " + temperature
            + "F degrees and " + humidity + "% humidity");
    }
}
```

This display implements *Observer* so it can get changes from the *WeatherData* object.

It also implements *DisplayElement*, because our API is going to require all display elements to implement this interface.

The constructor is passed the *weatherData* object (the *Subject*) and we use it to register the display as an observer.

When *update()* is called, we save the temp and humidity and call *display()*.

The *display()* method just prints out the most recent temp and humidity.

# Implementing the Weather Station

```
public class WeatherStation {  
    public static void main(String[] args) {  
        WeatherData weatherData = new WeatherData();  
  
        CurrentConditionsDisplay currentDisplay =  
            new CurrentConditionsDisplay(weatherData);  
        StatisticsDisplay statisticsDisplay = new StatisticsDisplay(weatherData);  
        ForecastDisplay forecastDisplay = new ForecastDisplay(weatherData);  
  
        weatherData.setMeasurements(80, 65, 30.4f);  
        weatherData.setMeasurements(82, 70, 29.2f);  
        weatherData.setMeasurements(78, 90, 29.2f);  
    }  
}
```

First, create the WeatherData object.

If you don't want to download the code, you can comment out these two lines and run it.

Simulate new weather measurements.

Create the three displays and pass them the WeatherData object.



# Observer Pattern

- Power of loose coupling
  - The only thing the subject knows about an observer is that it implements a certain interface.
  - We can add new observers at any time.
  - We never need to modify the subject to add new types of observers.
  - We can reuse subjects or observers independently of each other.
  - Changes to either the subject or an observer will not affect the other.
- Allows flexible OO systems that can handle changes easily, because they minimize the interdependency between objects.

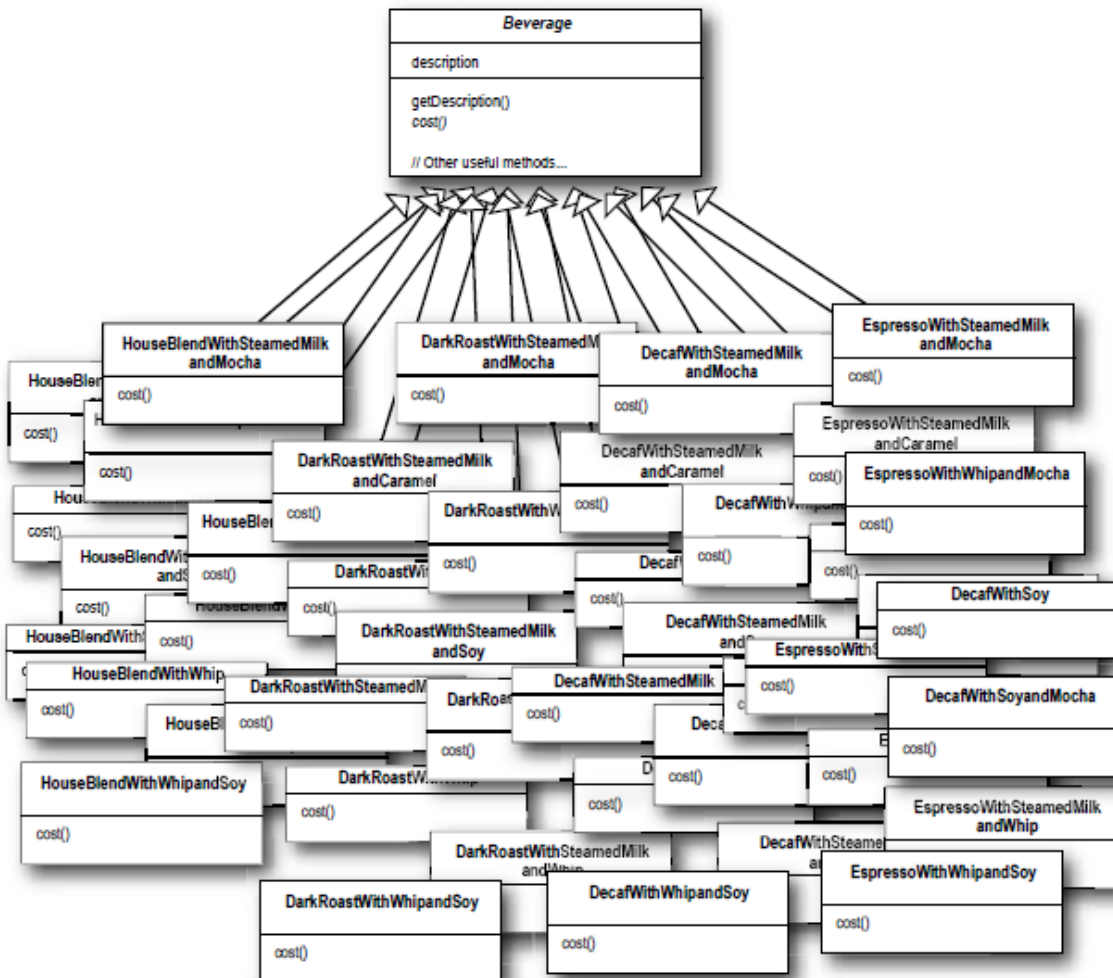
# Observer Pattern

- GoF Intent: “Defines a one-to-many dependency between objects so that when one object *changes state*, all of its dependents are notified and updated automatically.”
- Java’s built-in support for the observer pattern
  - `java.util.Observer`
  - `java.util.Observable`
- Listener method model for Swing API



# Decorator Pattern

## ■ Starbuzz Coffee



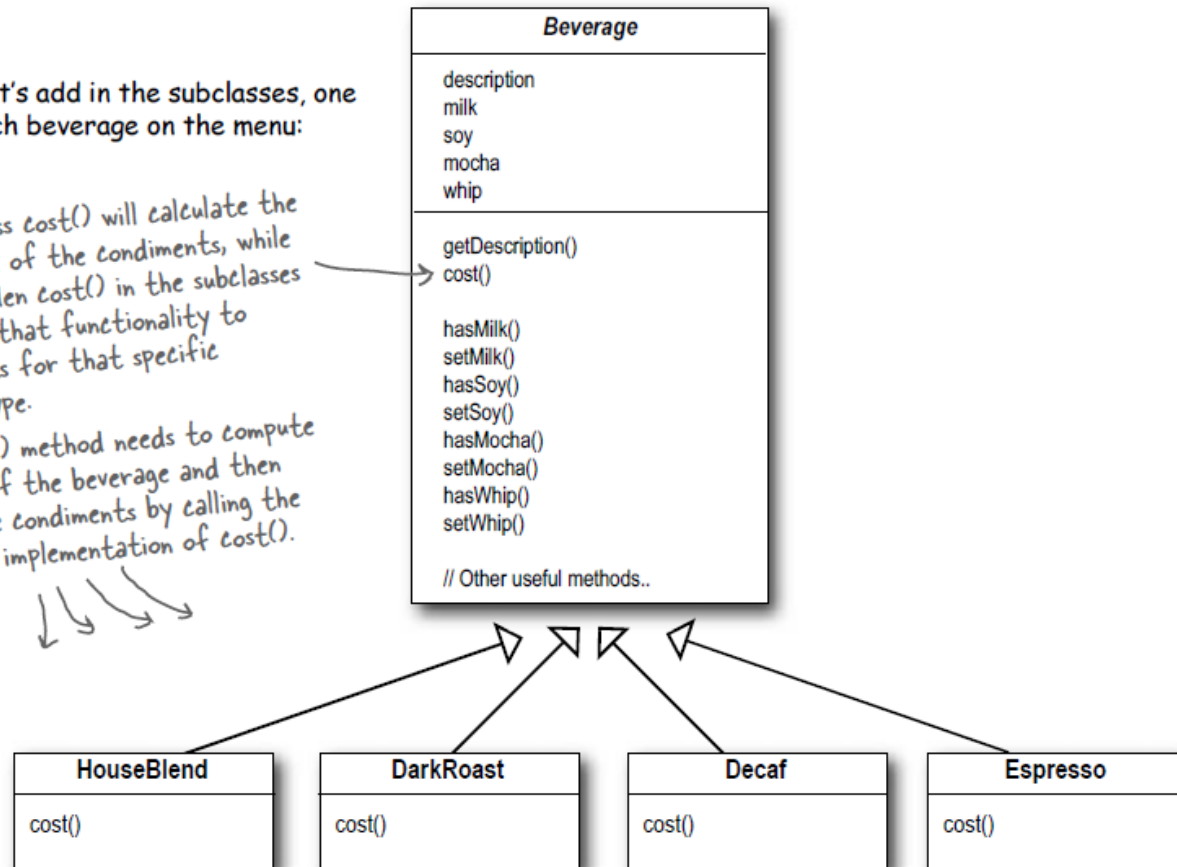
Starbuzz Coffee	
Coffees	
House Blend	.89
Dark Roast	.99
Decaf	1.05
Espresso	1.99
Condiments	
Steamed Milk	.10
Mocha	.20
Soy	.15
Whip	.10

# Starbuzz Coffee (Introduction to Decorator)

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

The superclass `cost()` will calculate the costs for all of the condiments, while the overridden `cost()` in the subclasses will extend that functionality to include costs for that specific beverage type.

Each `cost()` method needs to compute the cost of the beverage and then add in the condiments by calling the superclass implementation of `cost()`.





# Starbuzz Coffee (Introduction to Decorator)

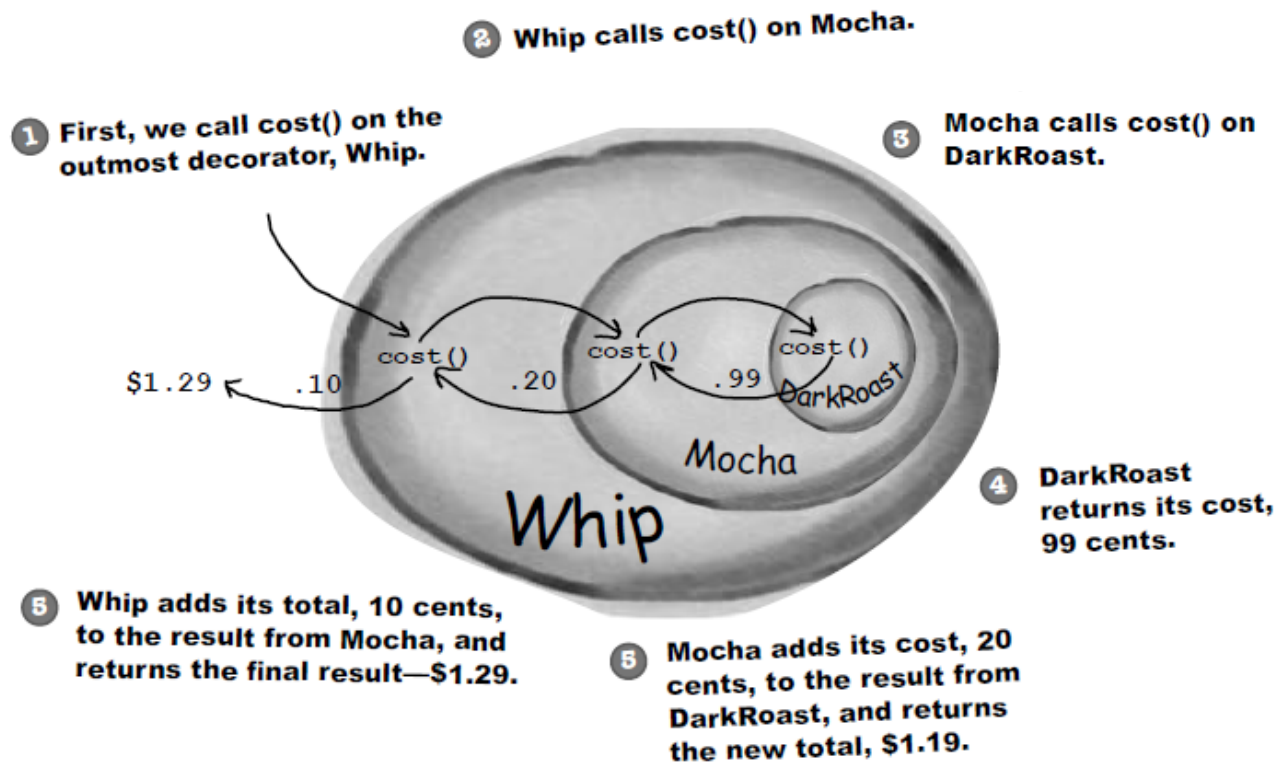
- The Open-Closed Principle: “Classes should be open for extension, but closed for modification.”
  - Our goal is to allow classes to be easily extended to incorporate new behavior without modifying existing code.
  - We’re going to strive to design our system so that the closed parts are isolated from our new extensions.
- Designs that are resilient to changes and flexible enough to take on new functionality to meet changing requirements

# Meet the Decorator Pattern

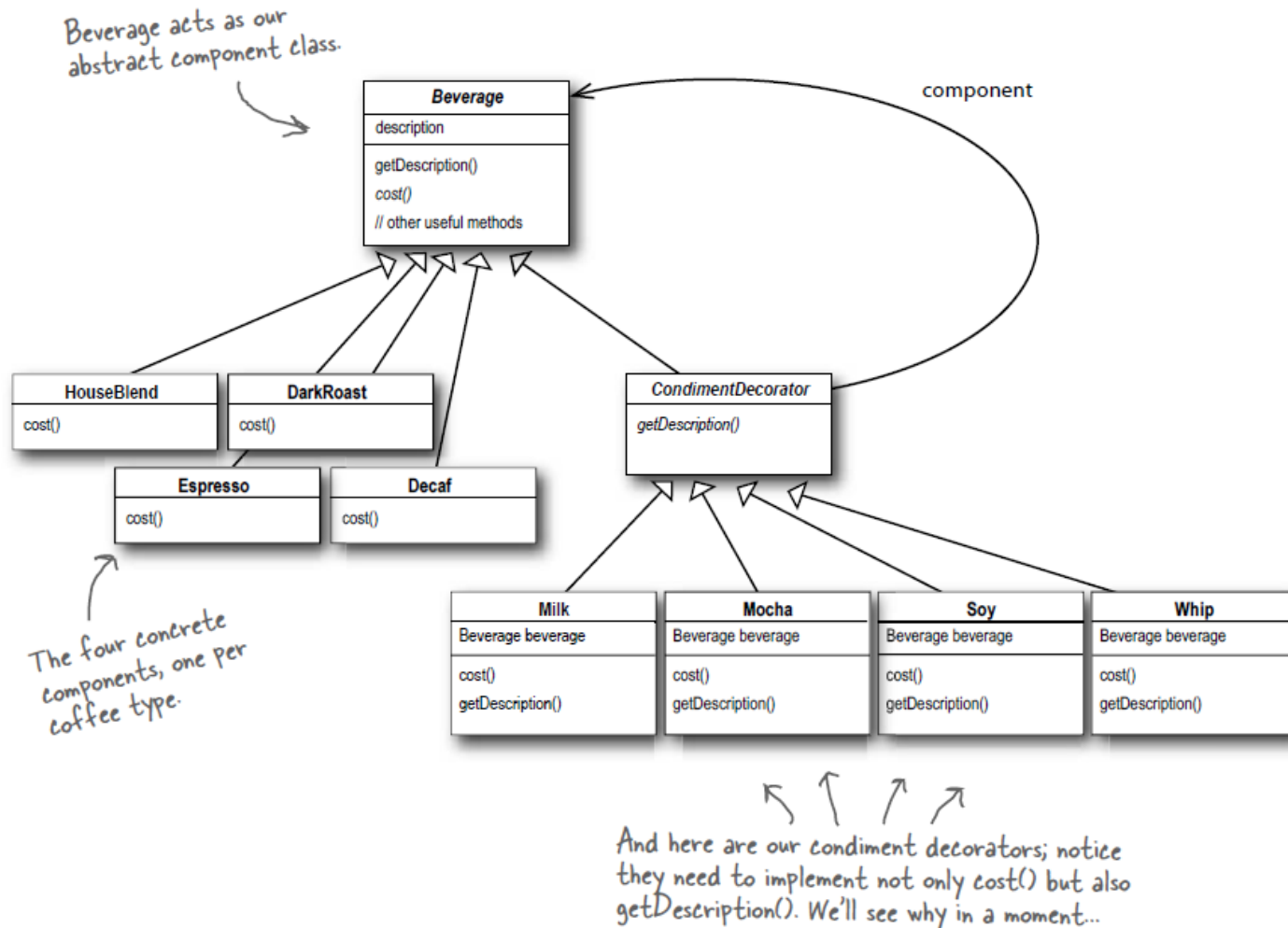
- We'll start with a beverage and “decorate” it with the condiments at runtime.
- For example, if the customer wants a Dark Roast with Mocha and Whip, then we'll:
  - Take a DarkRoast object
  - Decorate it with a Mocha object
  - Decorate it with a Whip object
  - Call the cost() method and rely on delegation to add on the condiment costs

# Meet the Decorator Pattern

- We can compute the cost 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.



# Decorating our Beverages



# Writing the Starbuzz code

```
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.

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

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

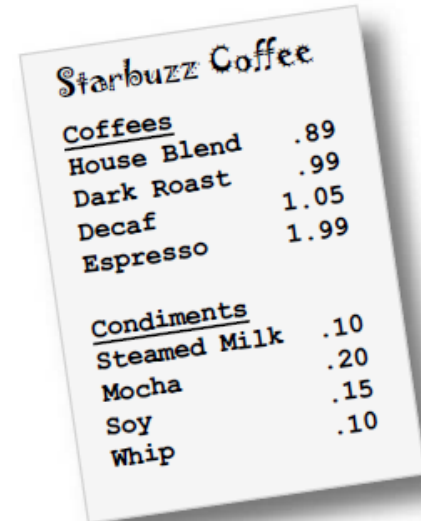
# Writing the Starbuzz code

```
public class HouseBlend extends Beverage {  
    public HouseBlend() {  
        description = "House Blend Coffee";  
    }  
  
    public double cost() {  
        return .89;  
    }  
}
```

```
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 instance 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.



A menu for Starbuzz Coffee. It is tilted slightly to the right. The title 'Starbuzz Coffee' is at the top in a stylized font. Below it, the word 'Coffees' is underlined. There are four items listed: 'House Blend' for \$.89, 'Dark Roast' for \$.99, 'Decaf' for \$1.05, and 'Espresso' for \$1.99. Below the coffee section, the word 'Condiments' is underlined. There are three items listed: 'Steamed Milk' for \$.10, 'Mocha' for \$.15, and 'Whip' for \$.10.

Starbuzz Coffee	
<u>Coffees</u>	
House Blend	.89
Dark Roast	.99
Decaf	1.05
Espresso	1.99
<u>Condiments</u>	
Steamed Milk	.10
Mocha	.15
Soy	.15
Whip	.10



# Writing the Starbuzz code

Mocha is a decorator, so we extend `CondimentDecorator`.

Remember, `CondimentDecorator` extends `Beverage`.

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 pass the beverage we're wrapping to the decorator's constructor.

```
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();
    }
}
```

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.

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.

# Serving some coffees

```
public class StarbuzzCoffee {
```

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

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

```
        Beverage beverage2 = new DarkRoast();
```

Make a DarkRoast object.  
Wrap it with a Mocha.

```
        beverage2 = new Mocha(beverage2);
```

```
        beverage2 = new Mocha(beverage2);
```

Wrap it in a second Mocha.

```
        beverage2 = new Whip(beverage2);
```

Wrap it in a Whip.

```
        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());
```

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

```
    }
```

```
}
```

File Edit Window Help CloudsInMyCoffee

```
% java StarbuzzCoffee
```

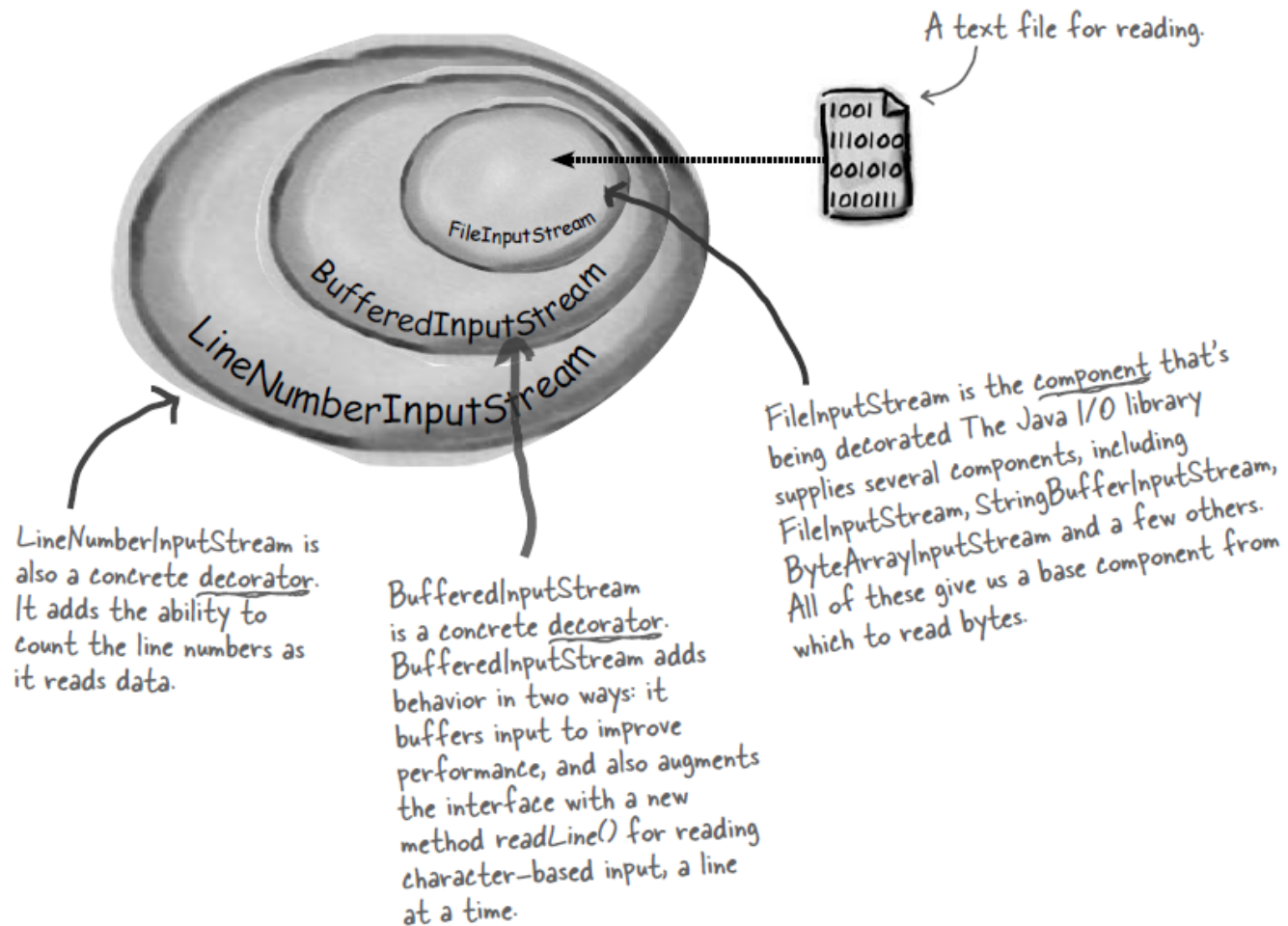
```
Espresso $1.99
```

```
Dark Roast Coffee, Mocha, Mocha, Whip $1.49
```

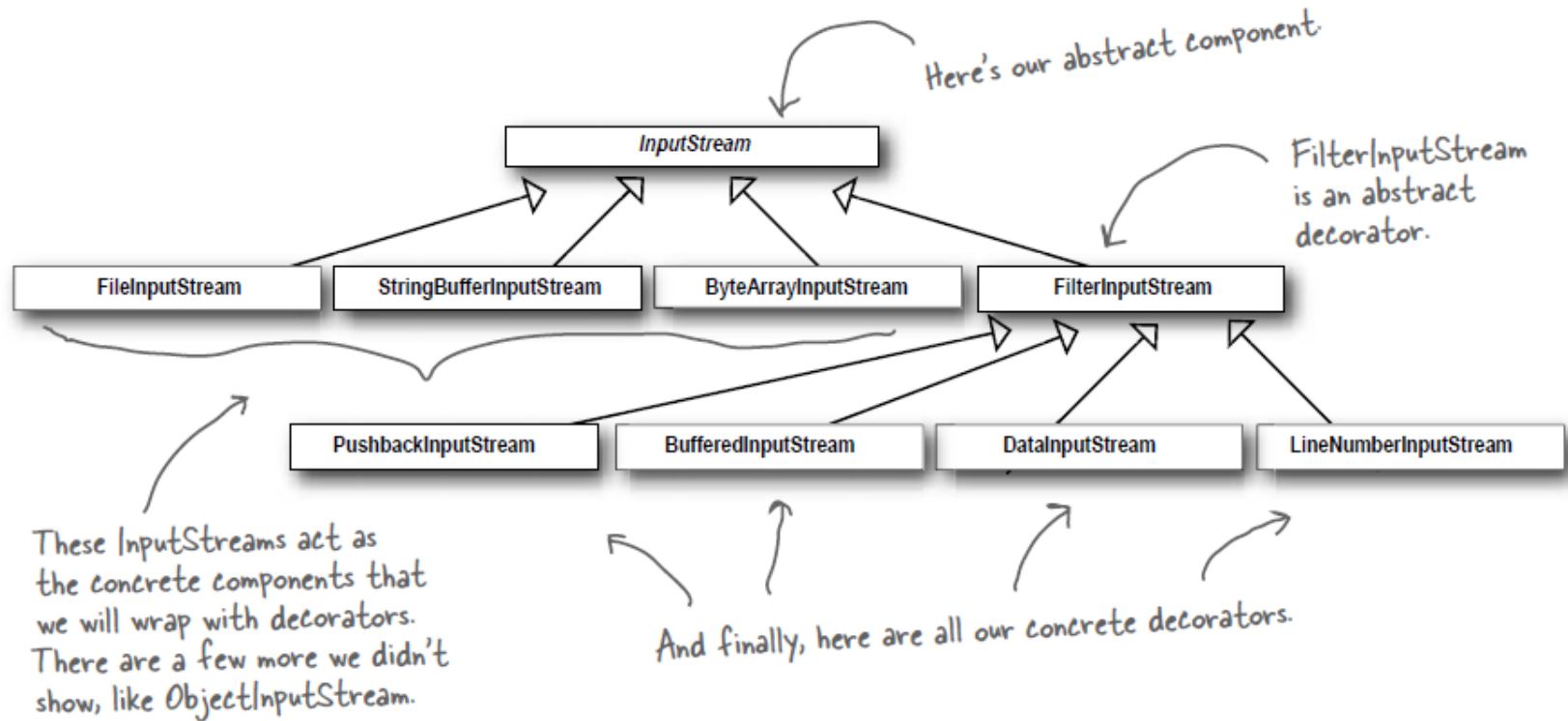
```
House Blend Coffee, Soy, Mocha, Whip $1.34
```

```
%
```

# Real World Decorators: Java I/O



# Real World Decorators: Java I/O





# Lab (Java I/O Package)

Writing your own Java I/O Decorator – Refer to the HFDP book



# Decorator

- GoF Intent: “Attach additional responsibilities to an object dynamically. Decorators provide a flexible alternative to subclassing for extending functionality.”