Decorator Pattern [GoF]

Intent

Attach additional capabilities to objects dynamically. Decorators provide a flexible alternative to subclassing for extending functionality.

Also Known As

Wrapper.

Motivation

Suppose you have a class that allows an application to write data to a file:

```
public class FileOutputStream {
   public FileOutputStream(String name);
   public write(byte[] data);
   public void flush();
   public void close();
}
```

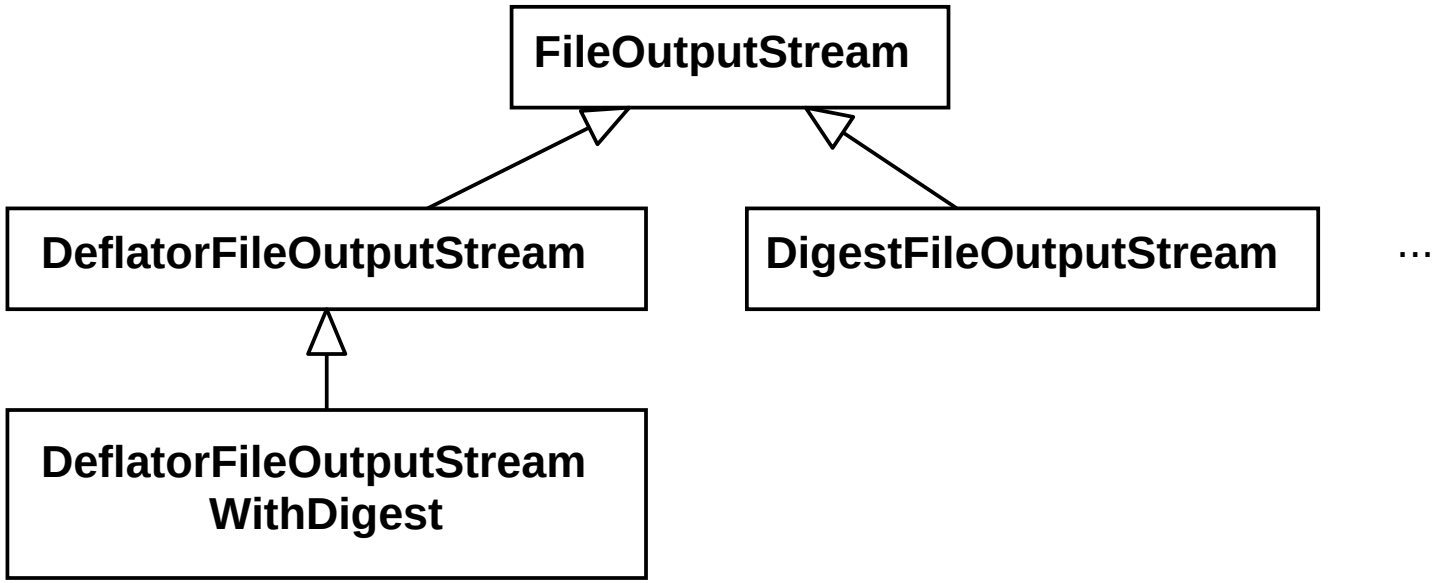
Imaging that the same or another application generates large data to be saved on disk. You decide to introduce another class that compresses the data:

```
public class DeflatorFileOutputStream extends FileOutputStr. {
   public void write(byte[] data);
}
```

Yet other applications may require additional responsibilities for writing data to files:

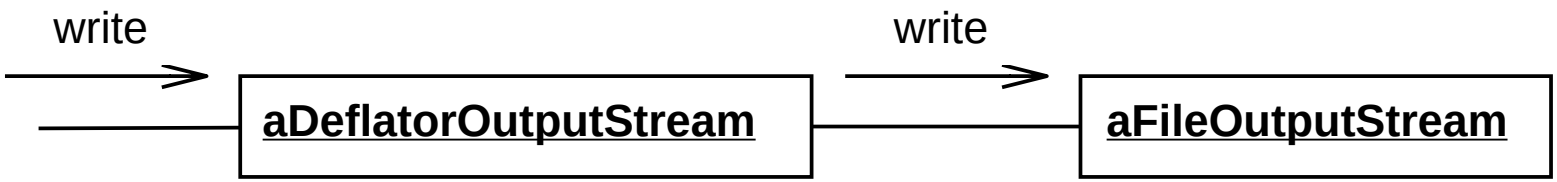
- some want to URL-encode strings before saving them on disk
- some want to create a digest (hash code) generated from the original data, and append it to the data to be saved on disk

Thus, you might end up with a “polluted” class hierarchy:



A more flexible strategy for achieving the required responsibility is to use object composition: You enclose the an object with a given responsibility into another one which *adds* additional responsibilities. For example, a `FileOutputStream` object has the responsibility to save data on disk. In order to save data in a com-

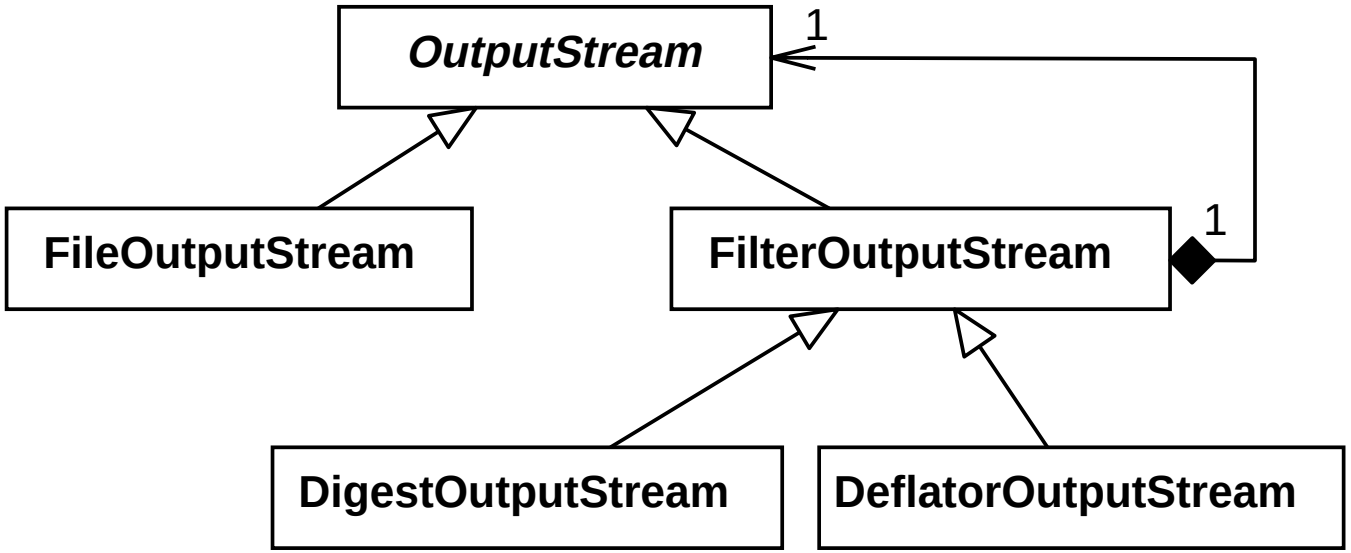
pressed way, compress it first by using a `DeflatorOutputStream` object which possesses the deflating responsibility only:



The client first creates a `FileOutputStream` object, and then encapsulates it with a `DeflatorOutputStream` object. Then, the client uses the `DeflatorOutputStream` object as it were merely a `FileOutputStream` object. The `DeflatorOutputStream` object is a sort of *decorator* for the `FileOutputStream` object.

However, it must be ensured that both objects provide the *same interface*. In addition, the decorating object must *delegate* its method invocations sooner or later to the decorated object.

This can be achieved by introducing the following class structure:



`OutputStream` is an abstract class for all kind of output stream objects. It defines the common interface for (output) stream-related methods such as several versions of `write`, `flush`, and `close`.

`FilterOutputStream` is a concrete (or abstract) class, the so-called *decorator*, that simply forwards any `OutputStream` method to its delegate, an `OutputStream` object.

Subclasses of `FilterOutputStream` can extend the behavior of the methods inherited by `FilterOutputStream`.

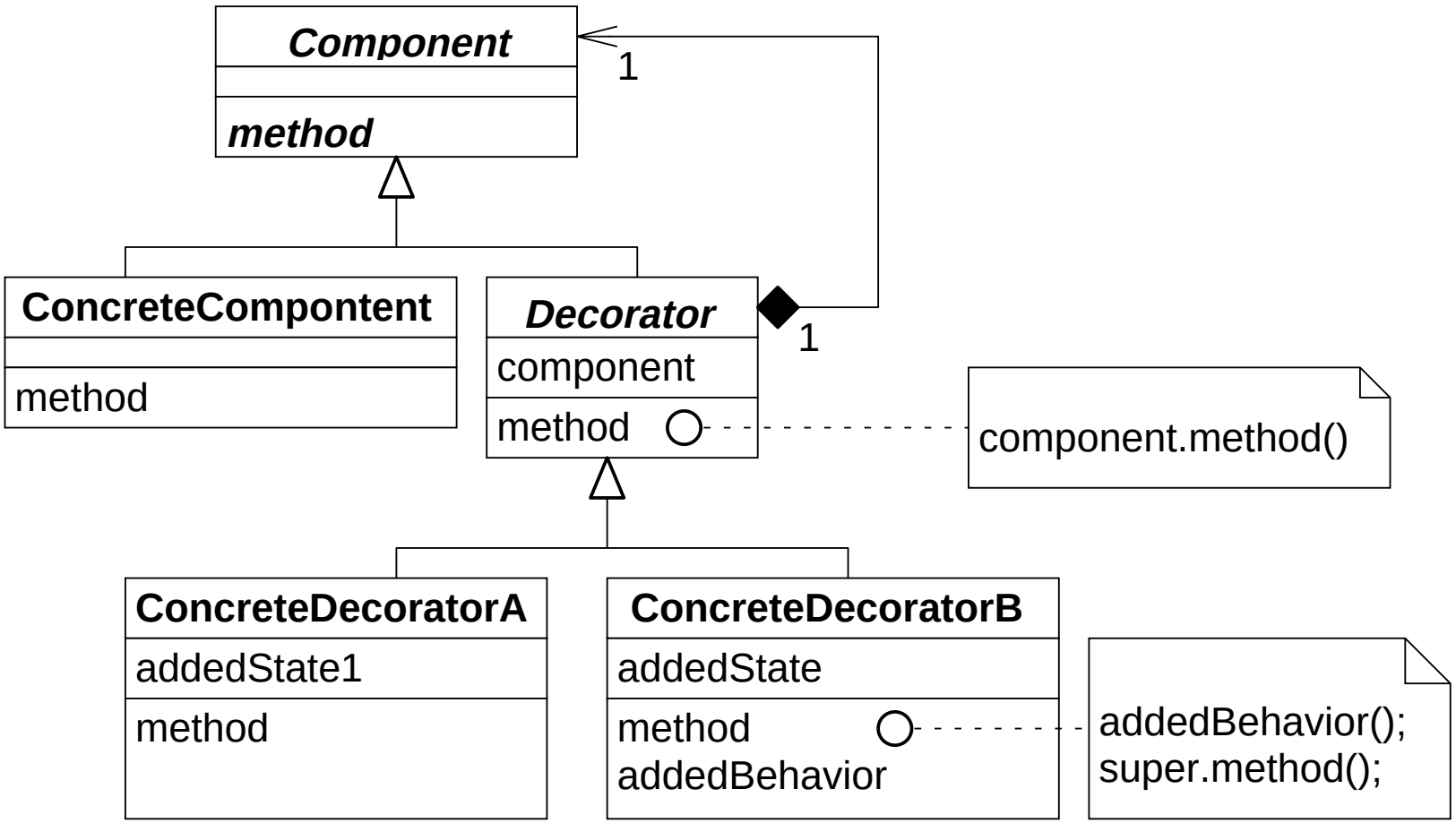
In addition, decorator subclasses are free to add specific functionality. For example, class `DeflatorOutputStream` may allow clients to call the `finish` method which finalizes the compression of data without closing the output stream.

Applicability

Use the Decorator pattern

- to add responsibilities to individual objects dynamically and transparently.
- for responsibilities that can be withdrawn.
- when extension by subclassing is impractical.

Structure


Component
method
1
ConcreteCompontent
method
Decorator
component
method
1
component.method()
ConcreteDecoratorA
addedState1
method
ConcreteDecoratorB
addedState
method
addedBehavior
addedBehavior();
super.method();

Participants

- **`Component`** (`OutputStream`)
  - defines the interface for objects that can have capabilities added to them
- **`ConcreteComponent`** (`FileOutputStream`)
  - defines an object to which additional capabilities can be attached
- **`Decorator`**
  - maintains a reference to a `Component` object and defines an interface that conforms to `Component`'s interface
- **`ConcreteDecorator`** (`DeflatorOutputStream`, `DigestOutputStream`)
  - adds capabilities to the component

Collaborations

- `Decorator` forwards requests to its `Component` object. It may optionally perform additional operations before and after forwarding the request.

Consequences

- More flexible than static inheritance.
- Avoids feature-laden classes high up in the hierarchy.
- A `Decorator` and its `Component` aren't identical.
- Lots of little objects.

Implementation

- A `Decorator` object's interface must conform to the interface of the component it decorates. `ConcreteDecorator` classes must inherit from a common class.
- Class `Decorator` can be made concrete when you need only to add one responsibility.
- Keep `Component` class lightweight.
- Decorator pattern is an alternative to the Strategy pattern: The decorator allows to change an object's behavior by wrapping the original object with a decorator. By contrast, with the Strategy pattern an object's behavior is changed by replacing a strategy object (which is not visible by the client) by another strategy object.

Sample Code

The following sample code illustrates the use of the Decorator pattern. We give sketches of Java's `java.io` package.

We start with the abstract class `OutputStream`:

```
public abstract class OutputStream {
   public abstract void write(int b) throws IOException;

   public void write(byte b[]) throws IOException {
      write(b, 0, b.length);
   }

   public void write(byte b[], int off, int len)
      throws IOException
   {
      // Perform some sanity checks. If OK then
      // write each byte in the byte array:
      for (....)
         write(b[some_index]);
   }

   public void flush() throws IOException {
   }

   public void close() throws IOException {
   }
}
```

Class `FileOutputStream` writes data to files. Details are not given:

```
public class FileOutputStream extends OutputStream {
   // Implements and/or overwrites the methods of
   // class OutputStream.
   // In addition, some additional, class-specific
   // methods are here, too.
}
```

Class `FilterOutputStream` is the decorator base class. It defines the default behavior of decorators. (Due to methodological reasons, class `FilterOutputStream` has been simplified.)

```
public class FilterOutputStream extends OutputStream {
   private OutputStream out;

   public FilterOutputStream(OutputStream out)
   {  this.out = out; }

   public void write(int b) throws IOException
   { out.write(b); }
   public void write(byte b[]) throws IOException
   { out.write(b, 0, b.length); }
   public void write(byte b[], int off, int len)
      throws IOException
   {  out.write(b, off, len); }
   public void flush() throws IOException
   { out.flush(); }
   public void close() throws IOException
   {  out.close(); }
}
```

Classes `DeflatorOutputStream` and `DigestOutputStream` are decorator subclasses. A sketch of `DeflatorOutputStream` is given next:

```
public class DeflatorOutputStream extends FilterOutputStream {
   protected byte[] buf;
   protected Deflator deflator;
   public DeflatorOutputStream(OutputStream os, Deflator d);
   public void write(byte[] b, int off, int len)
      throws IOException;
   public void write(int b) throws IOException;
   public void close() throws IOException;
   public void finish() throws IOException;
   protected void deflate() throws IOException;
}
```

An application wanting to store text strings as URL-encoded strings may use an URL encoding filter:

```
public class UrlEncodeOutputStream
   extends FilterOutputStream
{
   // Use class java.net.URLEncoder to encode String
   // objects, left as an exercise.
   // Provide a method public void writeString(String s).
}
```

The application then can store text to disk in URL-encoded and deflated form:

```
Deflator defl = ...;
UrlEncodeOutputStream os = new UrlEncodeOutputStream(
                      new DeflatorOutputStream(
                         new FileOutputStream("file"), defl));
String s = ...; // string that must become URL-encoded
os.writeString(s);
```

Related Patterns

- Adapter: A decorator is different from an adapter in that a decorator only changes an object's responsibility, not its interface.
- Strategy: A decorator lets you change the skin; a strategy lets you change the interior.