

Structural Design Patterns

Motivation and Examples

Ahmed Khattab

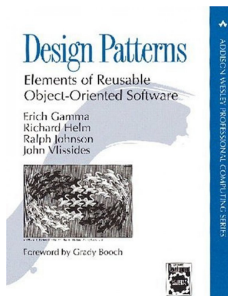
Technische Universität München

Patterns and Anti-Patterns, 28th of April 2015

- 1 Introduction
- 2 Structural patterns: definition
- 3 Examples of structural patterns
 - Proxy Pattern
 - Decorator Pattern
 - Façade Pattern
- 4 Structural patterns in action
 - The Weather App
 - Pacman

- 1 Introduction
- 2 Structural patterns: definition
- 3 Examples of structural patterns
 - Proxy Pattern
 - Decorator Pattern
 - Façade Pattern
- 4 Structural patterns in action
 - The Weather App
 - Pacman

*Design Patterns: Elements of Reusable Object-Oriented Software, 1994.*¹



Written by: Gamma, Helm, Johnson and Vlissides (aka. The Gang of four)

¹<http://c2.com/cgi/wiki?DesignPatternsBook>

Categorizing patterns

In the GoF book, patterns were classified according to their *purpose*. According to this classification, patterns can have either a **creational**, **structural**, or **behavioral** purpose.

- 1 Introduction
- 2 Structural patterns: definition
- 3 Examples of structural patterns
 - Proxy Pattern
 - Decorator Pattern
 - Façade Pattern
- 4 Structural patterns in action
 - The Weather App
 - Pacman

Definition

- Concerned with how object are composed to form more complex structures
- Provide simple ways to realize relationships between objects

Definition

- Concerned with how object are composed to form more complex structures
- Provide simple ways to realize relationships between objects

Motivation

- Flexibility to change
- Extensibility
- Structured code reuse

Examples of structural patterns

- Adapter Pattern
- Composite Pattern
- Decorator Pattern
- Bridge Pattern
- Façade Pattern
- Flyweight Pattern
- Proxy Pattern
- Aggregate Pattern
- ...

Our focus

Our focus will be on:

- Adapter Pattern
- Composite Pattern
- Decorator Pattern
- Bridge Pattern
- Façade Pattern
- Flyweight Pattern
- Proxy Pattern
- Aggregate Pattern
- ...

- 1 Introduction
- 2 Structural patterns: definition
- 3 Examples of structural patterns**
 - Proxy Pattern
 - Decorator Pattern
 - Façade Pattern
- 4 Structural patterns in action
 - The Weather App
 - Pacman

Definition

- Sits between the client of an object and the object itself
- Controls access to the object

Definition

- Sits between the client of an object and the object itself
- Controls access to the object

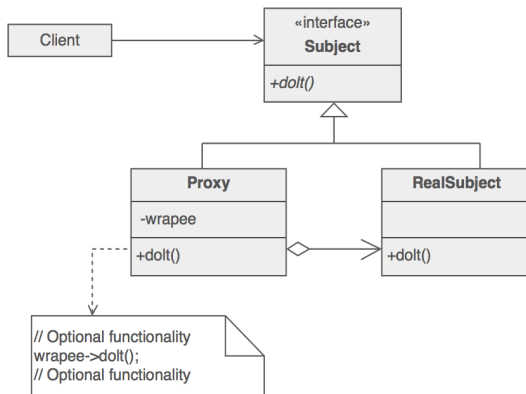
Common Scenarios

- Controlling the instantiation of an expensive object
- Making a remote object seem local
- Caching (web service requests, rendering of graphical elements, ...)

Proxy Pattern - The analogy



Proxy Pattern - In Detail



- 1 Introduction
- 2 Structural patterns: definition
- 3 Examples of structural patterns**
 - Proxy Pattern
 - **Decorator Pattern**
 - Façade Pattern
- 4 Structural patterns in action
 - The Weather App
 - Pacman

Decorator Pattern

Definition

- Allowing the addition of functionality to an object dynamically
- Provide a flexible alternative to subclassing for extending functionality

Decorator Pattern

Definition

- Allowing the addition of functionality to an object dynamically
- Provide a flexible alternative to subclassing for extending functionality

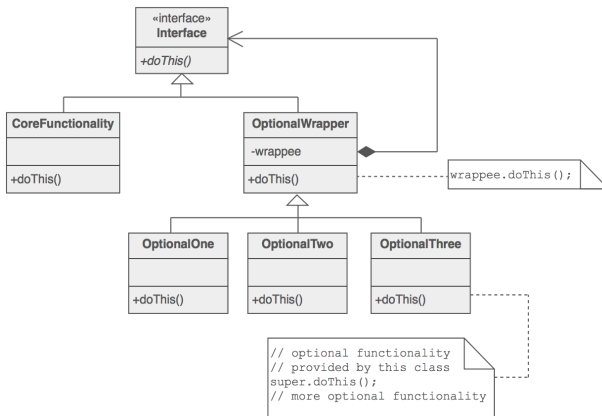
Common Scenarios

- Adding additional features to objects without heavily modifying the code using them
- Too many dynamic options that can be added, making subclassing a headache
- e.g. Lord of the rings game, different roles (elf, orc, hobbit, etc..)

Decorator Pattern - The analogy



Decorator Pattern - In Detail



- 1 Introduction
- 2 Structural patterns: definition
- 3 Examples of structural patterns**
 - Proxy Pattern
 - Decorator Pattern
 - Façade Pattern**
- 4 Structural patterns in action
 - The Weather App
 - Pacman

Definition

- Provides a simpler abstracted interface to a larger (potentially more complex) body of code.

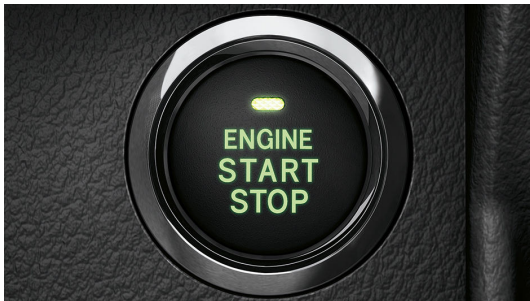
Definition

- Provides a simpler abstracted interface to a larger (potentially more complex) body of code.

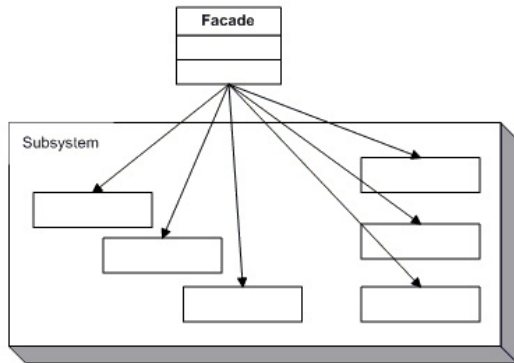
Common Scenarios

- Interface to abstract access to several complex subsystems
- Wrap a poorly designed collection of APIs with a single well-designed API

Façade Pattern - The analogy



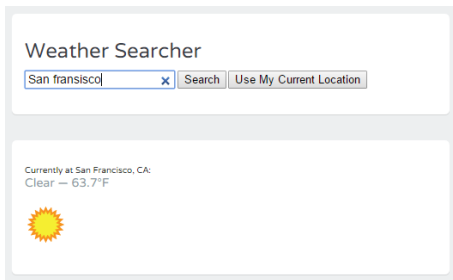
Façade Pattern - In Detail



- 1 Introduction
- 2 Structural patterns: definition
- 3 Examples of structural patterns
 - Proxy Pattern
 - Decorator Pattern
 - Façade Pattern
- 4 Structural patterns in action
 - The Weather App
 - Pacman

The Weather App²

A simple application for fetching location-specific weather information from a web service



²<https://github.com/flamingveggies/weathersearcher>

The Weather App

Upon no location match: a list of suggested locations is returned

Weather Searcher

Multiple Results Found:

Cairo, Egypt

Cairo, GA

Cairo, IL

Cairo, MO

Cairo, NE

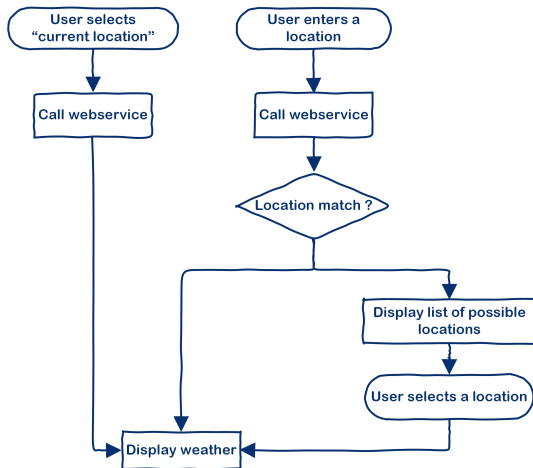
Cairo, NY

Cairo, OH

Cairo, WV

The Weather App

The flow:



The Weather App - analysis

The callback function handles everything

- Receiving response from webservice calls
- Parses and displaying weather info when available
- Otherwise displays list of possible locations and attaches event handlers for the displayed list

Disadvantages

- Tight coupling between view and control (handling web service calls and rendering of the output in one place)
- Suggestions for locations are fetched and the whole list is rendered every time from the web service (Caching ?)

The Weather App - refactoring I

The proxy:

```
function API() {
  this.cache = {};

  this.addToCache = function(location, data){
    this.cache[location] = data;
  }
  this.searchLocation = function(searchLocation, callback){
    if(this.cache[searchLocation])
      // cache hit, load from cache
    else
      // cache miss, call web service
  }
  this.getWeatherByID = function(searchID, callback){
    var url = " ... ";
    ...
  }
}
```

The proxy: a class API that provides the following:

- Encapsulates actual calls to the web service
- Manages the cache for caching the returned lists of locations

The Weather App - refactoring II

The decorator:

```
function BasicResponse(data) {  
    this.decorator;  
    this.data = data;  
}
```

```
BasicResponse.prototype.render = function() {  
    var resultHTML;  
    if(this.decorator) {  
        // a decorator exists, use it to render  
        decorators[this.decorator].render(this.data);  
    }  
    else {  
        // no decorators added, render normally...  
    }  
}}
```

The Weather App - refactoring II

The decorator:

```
//declare the different decorators
decorators = {};
decorators.locationsResponse = {
  render: function(data) {
    //do custom rendering for locations suggestions list...
  }
};

...

var weatherResponse = new BasicResponse(data);
if(data.locations != '') {
  weatherResponse.decorate('locationsResponse');
}
weatherResponse.render();
```

The **BasicResponse** class provides the following:

- An object oriented representation for each response from the web service
- A render method to parse and display normal responses
- The render method can be decorated to display special responses differently

- 1 Introduction
- 2 Structural patterns: definition
- 3 Examples of structural patterns
 - Proxy Pattern
 - Decorator Pattern
 - Façade Pattern
- 4 Structural patterns in action
 - The Weather App
 - Pacman

Pacman³

The famous Pacman implemented in JavaScript and HTML5 canvas



³<https://github.com/bxia/Javascript-Pacman>

- Script responsible for representing the Ghost object
- Handles rendering of the object using HTML5 canvas methods
- Every ghost can take different forms (color, eye position, ...)



Pacman - analysis

A huge Ghost.draw() function:

- Checks the status of the ghost (weak or strong, moving or not, ..)
- Draws every detail (the eyes, mouth, legs, ...)

```
// LEGS
if (!this.isMoving) {
    ctx.lineTo(this.x-this.radius, this.y+this.radius);
    ctx.lineTo(this.x-this.radius+this.radius/3, this.y+this.radius-this.radius/4);
    ctx.lineTo(this.x-this.radius+this.radius/3*2, this.y+this.radius);
    ctx.lineTo(this.x, this.y+this.radius-this.radius/4);
    ctx.lineTo(this.x+this.radius/3, this.y+this.radius);
    ctx.lineTo(this.x+this.radius/3*2, this.y+this.radius-this.radius/4);

    ctx.lineTo(this.x+this.radius, this.y+this.radius);
    ctx.lineTo(this.x+this.radius, this.y);
}
else {
    ctx.lineTo(this.x-this.radius, this.y+this.radius-this.radius/4);
    ctx.lineTo(this.x-this.radius+this.radius/3, this.y+this.radius);
    ctx.lineTo(this.x-this.radius+this.radius/3*2, this.y+this.radius-this.radius/4);
    ctx.lineTo(this.x, this.y+this.radius);
    ctx.lineTo(this.x+this.radius/3, this.y+this.radius-this.radius/4);
    ctx.lineTo(this.x+this.radius/3*2, this.y+this.radius);
    ctx.lineTo(this.x+this.radius, this.y+this.radius-this.radius/4);
    ctx.lineTo(this.x+this.radius, this.y);
}
```

A huge `Ghost.draw()` function:

- Checks the status of the ghost (weak or strong, moving or not, ..)
- Draws every detail (the eyes, mouth, legs, ...)

```
case UP:
    ctx.fillStyle="black"; //left eyeball
    ctx.beginPath();
    ctx.arc(this.x-this.radius/3, this.y-this.radius/5-this.radius/6, this.radius/6, 0, Math.PI*2, true);
    ctx.fill();

    ctx.fillStyle="black"; //right eyeball
    ctx.beginPath();
    ctx.arc(this.x+this.radius/3, this.y-this.radius/5-this.radius/6, this.radius/6, 0, Math.PI*2, true);
    ctx.fill();
break;
```


A huge `Ghost.draw()` function:

- Checks the status of the ghost (weak or strong, moving or not, ..)
- Draws every detail (the eyes, mouth, legs, ...)

Disadvantages

- Hard to understand, to maintain, or to debug.
- Repetitive very similar lines of code, no reuse.

Façade:

- Re-structured the draw() function by using several helper functions
- Reuse of code for drawing eyes at different positions, as well as legs

```
Ghost.prototype.eyeBlack = function (offsetX, offsetY){ ... };
```

```
Ghost.prototype.eyeWhite = function (){ ... };
```

```
Ghost.prototype.legs = function (){ ... };
```

```
Ghost.prototype.mouth = function (){ ... };
```

Façade:

```
Ghost.prototype.eyeBlack = function (offsetX, offsetY){
    ctx.fillStyle="black";
    ctx.beginPath();
    ctx.arc(this.x+offsetX, this.y+offsetY, this.radius/6, 0,
        Math.PI*2, true);
    ctx.fill();
};

Ghost.prototype.draw = function () {
    ...
    case UP:
        this.eyeBlack(-this.radius/3, -this.radius/5-this.radius/6);
        this.eyeBlack(this.radius/3, -this.radius/5-this.radius/6);
    break;
    ...
}
```

The decorator pattern:

- Objects can be 'decorated' and used with new behavior, without worrying about modifying the base object.
- Excessive use is not advised, managing them becomes a headache (instantiation of objects, decorators interdependence, ..)

The proxy pattern:

- Introduces a level of indirection that helps in regulating or optimizing access to objects
- While making access to remote objects completely transparent, inefficient uses can occur

```
if (account.getBalance() > 0 && account.getBalance() < MAX) {  
    transferAmount(account.getBalance() / 2);  
}
```

The façade pattern:

- Promotes decoupling and reuse, enhances structure and maintainability of code.
- Need to be aware of the performance costs of the abstraction offered by the façade

Interesting to compare:

- **Adapter** provides a different interface to its subject. **Proxy** provides the same interface. **Decorator** provides an enhanced interface.
- https://sourcemaking.com/design_patterns/structural_patterns

References



Stefanov, S.
JavaScript Patterns.
O'Reilly Media, 2010.



Osmani, A.
Learning JavaScript Design Patterns.
O'Reilly Media, 2012.



Gamma, E. and Helm, R. and Johnson, R. and Vlissides, J.
Design Patterns: Elements of Reusable Object-oriented Software.
Addison-Wesley Longman Publishing Co., 1994.



Sourcemaking
Design Patterns Explained Simply.
https://sourcemaking.com/design_patterns



Zaikin, M.
Benefits and Drawbacks of Design Patterns.

<http://java.boot.by/scea5-guide/ch07s03.html>