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Analysis, Design and Implementation

Topic 8:

Design Patterns (2)

Introduction

- In the last lecture, we looked at the concept of design patterns and examined two particular patterns available to us.
- In this lecture, we are going to look at a range of other patterns, how they can be used, and why they are beneficial.
- Patterns cover a wide range of possible situations, and a good understanding of what is out there is important in knowing when to use them.
- There are many more than we have time to cover.
    - You should research the topic yourself to find new and interesting patterns.

Structural Design Patterns

- All structural patterns derive from two guidelines:
  - Isolate variation in classes
  - Create a separate class for each variable part of a model.
- If you have a method that must change dependant on the type of object it is working with, consider extracting it out and making it a class of its own.
- The first two patterns we’re going to look at are structural patterns.
  - The ***MVC*** and the ***Facade***

The Model View Controller

- We have avoided discussing user interfaces thus far in the module, as we’ve been waiting for this pattern.
- It is common practice for beginning developers to embed functionality into the code that handles the presentation. This tightly binds your functionality to the context in which it is delivered.
- This causes problems later on down the line.

MVC - 1

- The Model View Controller architecture addresses this by providing a clean separation of roles in a program:
  - The model, which handles the 'business logic'
  - The view, which handles the presentation of the state of the model to the user
  - The controller, which allows for the user to interact with the model.

MVC - 2

- In simple programs, the view and the controller may be the same class.
  - They will be for the purposes of our module, but real world programs may use separate classes for each.

MVC - Model

- The model defines all the state and functionality of a system.
  - Everything except presenting information to the user.
- The model makes ***no assumptions*** with regards to the view of the data.
  - It doesn’t matter to the model if the view is a GUI, a phone display, or a text interface.
- The model may be represented by a single class.
  - More usually, it will be represented by several classes.

MVC - View

- The view handles the presentation.
  - It's the user interface.
- The view has absolutely no code for altering the state of the system.
  - It sends queries to the model, and the model sends the answers back.
- The only code contained within the view is view-specific code.
  - Turn an array of strings into a combo box, for example.

MVC - Controller

- The controller is what provides the user’s ability to manipulate the system.
  - It’s usually represented by the event handlers for the controls that belong to the view.
- In an ideal world, the controller is an entirely separate class to the view.
  - For small, simple programs this is often over-engineering.
- The controller defines the ‘stitching’ between the view and the model.

Value of Decoupling - 1

- Why is it so important we separate out the model from the view?
  - Division of responsibilities allows for parallel development:
    - Model best handled by technical teams.
    - View best handled by GUI specialists.
    - All that teams must agree on is the ***interface*** between the different parts of the system.

Value of Decoupling - 2

- It allows for flexibility of deployment and maintenance.
  - A new interface can be ‘bolted on’ with minimal difficulty.

Facade - 1

- When a model is especially complex, it can be useful to add in an additional pattern to help manage the external interface of that model.
  - That pattern is called a ***facade***.
- A facade sits between the view/controller and provides a stripped down or simplified interface to complex functionality.
  - This comes at a cost though, in terms of coupling and cohesion.
- A facade is another ***structural*** pattern.

Facade - 2

- A facade provides significant benefits:
  - Makes software libraries easier to use by providing helper methods
    - It can be difficult to work out how objects should relate in a complex class hierarchy.
  - Makes code more readable
  - Can abstract away from the implementation details of a complex library or collection of classes.
  - Can work as a wrapper for poorly designed APIs, or for complex compound relationships between objects.

Example – In A Controller

```
public class FacadeExample {
    public SomeOtherClass handleInput (String configInfo) {
        return myFacade.doSomeMagic (configInfo);
    }
}

public class Facade {
    SomeClass one;
    SomeOtherClass two;
    SomeKindOfConfigClass three;

    public SomeOtherClass doSomeMagic (String configInfo) {
        three = new SomeKindOfConfigClass (configInfo)
        one = new SomeClass (three);
        two = one.getSomethingOut ();
        return two;
    }
}
```

Facade - 3

- The more code that goes through the facade, the more powerful it becomes.
  - If just used in one place, it has limited benefit.
- Multiple objects can make use of the facade. This greatly increases the ease of development and reducing the impact of change.
- All the user has to know is what needs to go in, and what comes out. The facade hides the rest.

Facade Downsides

- This comes with a necessary loss of control.
  - You don’t really know what’s happening internally.
- Facades are by definition simplified interfaces, so you may not be able to fully utilise functionality locked behind one.
- Facades increase structural complexity.
  - It’s a class that didn’t exist before.
- Facades increase coupling and reduce cohesion.
  - They often have to link everywhere, and the set of methods they expose often lack consistency

The Strategy Pattern - 1

- The strategy pattern is used to decouple the implementation from the context.
  - A somewhat esoteric pattern, but extremely powerful.

- It works by removing the hard-coding of functions in a class. Instead, we provide objects that can have different versions of a function available.

- Instead of writing code, we instead invoke a set method of the object we were provided.

The Strategy Pattern - 2

- Imagine the following situation:
  - You are developing a simple role-playing game where players can create one of a range of different kinds of characters.
  - Each can attack, defend, and cast spells.
  - However, different things can happen depending on what character you are.
  - All of the capabilities of each character class are accessed in the same way, but have different effects.

The Strategy Pattern - 3

- Wizards can
  - Attack and cast spells, but can’t defend.
- Assassins can
  - Attack and defend, but can’t cast spells
- Rogues can
  - Attack and defend, but can’t cast spells
- Witches can
  - Defend and cast spells, but can’t attack

The Strategy Pattern - 4

- Each class action is either identical to the others, or slightly different.
  - Everyone defends the same, but witches cast different spells to wizards.

The Strategy Pattern - 5

- How do you handle this?
  - Inheritance?
    - Only works in limited circumstances.
  - Abstract classes and Interfaces
    - Much duplication across classes.
  - A combination
    - Can be highly complex and difficult to modify
- Something else?
  - A behavioural pattern, perhaps.

The Strategy Pattern - 6

```
public class CharacterType {
    private AttackAction myAttack;
    private DefendAction myDefend;
    private SpellsAction mySpell;

    public CharacterType (AttackAction a, DefendAction d, SpellsAction s) {
        myAttack = a;
        myDefend = d;
        mySpell = s;
    }

    pubic performAttack() {
        myAttack.doAttack();
    }

    public performDefence() {
        myDefend.doDefence();
    }

    public performSpell() {
        mySpell.castSpell();
    }
}
```

The Strategy Pattern - 7

```
public class Rogue extends CharacterType() {
    public Rogue() {
        super (new StealthAttack(), new DodgeDefence(), null);
    }
}

public class Wizard extends CharacterType() {
    public Wizard() {
        super (new StaffAttack(), null, new DefendSpell());
    }
}

public class Assassin extends CharacterType() {
    public Assassin() {
        super (new DaggerAttack(), new DodgeDefence(), null);
    }
}

public class Witch extends CharacterType() {
    public Witch() {
        super (null, new ParryDefence(), new AttackSpell());
    }
}
```

The Strategy Pattern - 8

- Structurally, the strategy pattern allows the developer to resolve several systemic problems in single inheritance languages, such as C# and Java.
- At the cost of (often considerable) obfuscation of code, you gain exceptional control over the structure of objects.
- The easiest way of thinking about it is that you have functions that can be swapped in and out as needed.

The Strategy Pattern - 9

- This benefit extends beyond compile time.
  - You can actually ‘hot swap’ methods if needed. This in itself is a tremendous benefit.
- Much as with the factory, this allows us to simplify the logic of the programs that we write.
  - It also maps neatly onto a well defined state machine. We’ll see an example of this in the next lecture.
- We will also see it being used when we implement the design of the case study we saw previously.

The Flyweight - 1

- Object-oriented programming languages provide fine-grained control over data and behaviours.
  - But that flexibility comes at a cost. Objects are expensive to create and sometimes use up more memory than they need.
- The flyweight creational pattern is used to reduce the memory and instantiation cost when dealing with large numbers of finely-grained objects.
  - It does this by sharing state whenever possible.

Scenario

- Imagine a word processor.
  - They're pretty flexible. You can store decoration detail on any character in the text.
- How is this done?
  - You could represent each character as an object.
  - You could have each character contain its own font object…
  - … but that's quite a memory overhead.
- It would be much better if instead of holding a large font object, we held ***only a reference*** to a font object.

The Flyweight - 2

- The Flyweight pattern comes in to reduce the state requirements here.
    - It maintains a cache of previously utilised configurations or styles.
    - Each character is given a reference to a configuration object.
    - When a configuration is applied, we check the cache to see if it exists. If it doesn't, it creates one and add it to the cache.

The Flyweight - 3

- The Flyweight dramatically reduces the memory footprint of an object.
  - We have thousands of small objects rather than thousands of large objects.

Before and After

```
public class MyCharacterBefore {
    char letter;
    Font myFont;

    void applyDecoration (string font, int size);
        myFont = new Font (font, size);
    }
}

public class MyCharacterAfter {
    char letter;
    Font myFont;

    void applyDecoration (string font, int size);
        myFont = FlyweightCache.getFont (font, size);
    }
}
```

Implementing a Flyweight

- The flyweight patterns makes no implementation assumptions.
  - A reasonably good way to do it is through a hash map or other collection.

- The principle is the same as basic caching:
  - When a request is made, check the cache.
  - If it’s there, return it.
  - If it’s not, create it and put it in the cache and return the new instance.

Limitations of the Flyweight Pattern

- Flyweight is only an appropriate design pattern when object references have no context.
  - It doesn’t matter to what they are being applied.
- A font object is a good example.
  - It doesn’t matter if it’s being applied to a number, a character, or a special symbol.
- A customer object is a bad example.
  - Each customer is unique.

Conclusions

- The MVC design pattern is used to separate out parts of an application.
  - This simplifies development and makes maintenance easier.
- The facade is used to simplify complex object relationships.
- The strategy pattern is used to implement ‘hot swapping’ functionality.
- The flyweight pattern is used to reduce memory overhead.

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Any Questions?

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