Scope and Coverage

This topic will cover:

- The need for design patterns
- The factory design pattern
- The abstract factory design pattern

Learning Outcomes

By the end of this topic students will be able to:

- Understand the use of design patterns
- Design and use factory design patterns
- Design and use abstract factory design patterns

Introduction

- We have spent the past few lectures discussing primarily the analysis and design elements of building software.
- In this lecture we are going to explore some of the ways we can make our implementation more effective by making use of design patterns.
- Design patterns are particular software development techniques that can be used to achieve design goals.

Design Patterns

- As part the design process of building a piece of software, we encounter situations that we think will be difficult to write in code,
  - Any time you think to yourself ‘I am not sure how this is best done’
- Design patterns are collections of objects and classes that are aimed at meeting a particular design need.
  - There are many dozens of well established patterns, and we can only discuss a few of these.

Design Patterns

- Design patterns fill the role of ‘high level design’ in object oriented programs.
  - It is often difficult to develop ‘good’ object oriented solutions.
  - Design patterns are a shorthand for particular collections of objects, arranged in a particular way.
- Design patterns are **battle-tested**.
  - A pattern only enters into common acceptance when it has been shown to work in many situations – as such, we can be confident that it works.
- Design patterns are **generalised.**
  - A design pattern is to object design what an algorithm is to lines of code.
  - We need to write it with our specific context in mind.

Representing Design Patterns

- A design pattern is a collection of (usually) several different classes.
  - It defines the interaction of these objects at a higher level of abstraction.
  - The examples we see are just examples.
    - You need to implement them in the context of your own systems.
- They are not solutions themselves.
  - Just the 'shape' of solutions.

Benefits of Patterns

- Part of what design patterns bring to the field of software engineering is a common vocabulary for design
  - Shorthand solutions for certain kinds of recurring programming problems.
- Design patterns are 'best practice', and thus allow for portability of the 'lessons learned' of experienced developers.
  - They are an aid to learning.
    - You get the benefit of avoiding the mistakes others have made over the years.

Benefits of Patterns

- They fit in easily with existing modern programming techniques.
  - Design patterns complement object orientation
  - They are easily expressed as UML diagrams for the most part.
- Design patterns reduce the need for future large-scale refactoring.
  - They are tried and tested, and the result of successive refactoring of their own.

Criticisms of Patterns

- Some of the patterns that are in common usage are simple workarounds for missing language features.
  - Some patterns are repetitions of things supported syntactically in other languages.
- Can lead to systems that are heavily over-engineered.
  - Use with care – it's tempting to put patterns in when there is no real requirement.
- When you have a hammer…
  - Patterns represent good solutions to recurring problems, but they are no substitute for effective analysis.
- Counter-productive when building expertise.
  - You learn more from failure than you do from success.

Design Patterns

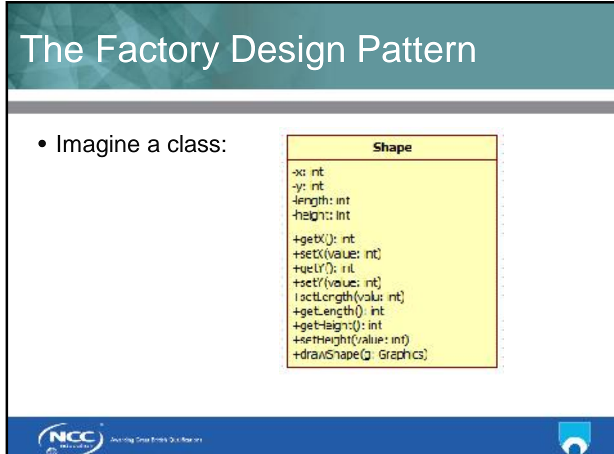
- Design patterns are broken down into a number of different categories.
  - Structural
  - Creational
  - Behavioural
- The first of the patterns that we are going to look at is called the **factory** design pattern.
  - This is a creational pattern.

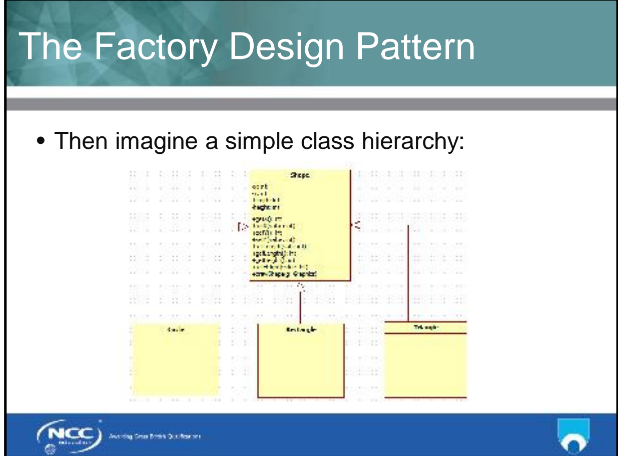
Creational Design Patterns

- We use creational design patterns for several reason:
  - Some situations are more complex than simple instantiation can handle.
    - Imagine for example you want to create an entirely 'skinnable' look and feel for an application.
  - Some situations have complex consequences if objects aren't instantiated in the right way or the right order.
  - Some situations require that only one object is ever created.

The Factory Pattern

- The Factory is used to provide a consistent interface to setup properly configured objects.
  - You pass in some configuration details
  - Out comes a properly configured object.
- At its simplest, it can be represented by a single class containing a single static method.
  - More complex factories exist, dealing with more complex situations.
    - Those are all variations on the basis structure we will discuss in the lecture.





The Factory Design Pattern

- Now imagine you are creating a simple drawing package.
  - User selects a shape
  - User clicks on the screen
  - Application draws the shape at that location.
- This can all be hard-coded directly into an application.
  - This suffers from scale and readability issues.
    - The application becomes a maze of if statements and switches.

The Factory Design Pattern

- Instead, we can use a factory to generate specific objects, through the power of **polymorphism**.
  - Polymorphism is key to the way a Factory works.
- The system that drives a factory is that all these shapes have a common parent class.
  - Thus, all we need is the Shape object that is represented by specific objects.
- The objects themselves manage the complexity of the drawing process.

The Factory Design Pattern

```
class ShapeFactory
  {
    public Shape getShape (String shape, int x, int y, int len, int ht, String colour) {
        Shape temp = null;

        if (shape.Equals ("Circle")) {
           temp = new Circle (x, y, len, ht);
        }

        else if (shape.Equals ("Rectangle")) {
           temp = new Rectangle (x, y, len, ht);
        }

        else if (shape.Equals ("Face")) {
           temp = new Face (x, y, len, ht);
        }

        temp.setDrawingColor (col);
        return temp;
     }
  }
```

The Factory Design Pattern

- The Factory Pattern reduces hard-coded complexity.
  - We don't need to worry about combinatorial explosion.
- The Factory Pattern properly devolves responsibility to individual objects.
  - We don't have a draw method in our application, we have a draw method in each specific shape.
- However, the Factory pattern by itself is limited to certain simple contexts.
  - For more complicated situations, we need more.

The Abstract Factory

- The next level of abstraction is the Abstract Factory.
  - This is a Factory **for** factories.
- Imagine here we have slightly more complicated situations.
  - Designing an interface that allows for different themes.
  - A file conversion application that must allow for different versions of different formats.
  - A bank that provides different kinds of accounts for their customers.

The Abstract Factory

- We could handle these with a factory by itself.
  - This introduces the same combinatorial problems that the factory is designed to resolve.
- A simple rule to remember is – coding combinations is usually bad design.
- Bad design causes trouble later on.
  - When doing anything more substantial than simple 'proof of concept' applications, we should always be sure to engineer our systems properly.

Abstract Factory Implementation

```
public class AbstractFactory {
   public static Factory getFactory (string look) {
      Factory temp;
      if (look.Equals ("windows")) {
         temp = new WindowsFactory();
      }

      else if (look.Equals ("linux")) {
         temp = new LinuxFactory();
      }

      else if (look.Equals ("macintosh")) {
         temp = new MacintoshFactory();
      }
      return temp;
   }
}
```

Factory Implementation

```
class ShapeFactory : Factory
  {
    public override Shape getShape (String shape, int x, int y, int len, int ht,
        String colour) {

        Shape temp = null;

        if (shape.Equals ("Circle")) {
           temp = new Circle (x, y, len, ht);
        }

        else if (shape.Equals ("Rectangle")) {
           temp = new Rectangle (x, y, len, ht);
        }

        else if (shape.Equals ("Face")) {
           temp = new Face (x, y, len, ht);
        }

        temp.setDrawingColor (col);
        return temp;
     }
  }
```

Factory Base Class

```
abstract class Factory {
    public abstract Shape getShape (String sh,
        int x, int y, int len, int ht,
        String c);
  }
```

The Consequence

- Entirely new suites of shapes and styles can be added to this system without risking combinatorial explosion.
  - The ‘operational’ code is also much tighter and more focused.

```
Factory myFactory =
AbstractFactory.getFactory ("pointilism");

Shape myShape = myFactory.getShape
("circle");
```

Using Patterns

- Patterns are best decided upon in the design phase of development.
  - During our analysis, we may encounter situations that require the creation of large amounts of objects.
- We use the factory and/or abstract factory when we must deal with potentially large combinations of objects that must be created and configured.
- If we see such a requirement, we make sure to place our design pattern in the appropriate part of our class diagram.

Using Patterns

- Much of deciding when we should use patterns is based on our own pattern recognition.
  - We see that a particular kind of functionality is going to be suited to a pattern of which we are aware.
- Experimenting with patterns is an important part of building that skill.
  - We have to see what patterns can do, how they do it, and how they can be moulded to meet our own specific needs.

Conclusion

- Design patterns are an important technique for handling the implementation of complex functionality.
  - They are something like algorithms for object and class design.
- The factory design pattern is used to handle the creation of objects that stem from a common base.
- Abstract factories are factories **for** factories.
  - We choose the factory we want, and use that to generate objects.