CS 407
Design Patterns

Design patterns: Designing generic components

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Generic components

- Also know as reusable components
- Extended or reused in many different contexts without having to change the code
- Two basic techniques
  - Refactoring
  - Generalization

Mechanisms

- To build generic components use
  - Inheritance
  - Delegation
- Abstract classes and interfaces also play key role

Refactoring

- Identify recurring code - same logic in multiple different places
- Capture the logic in a single place on a generic component
- Restructure program so all existing code uses generic implementation (ie. Remove duplication)

Why refactor

- Faster implementation of new components that use the method
- Bug fixes must be made in all duplicate methods making it easy to fix in someplaces but not all
- Duplicate code can lead to drifting of implementations making understanding of code more difficult even though same task done
- **Be careful not all code that looks alike is alike!**

Function/method refactoring

```
class Computation{
  void method1(){
    computeStep1();
    computeStep1();
    computeStep1();
  }
  void method2(){
    computeStep1();
    computeStep1();
    computeStep1();
  }
  …
}
```

```
class Computation{
  void computeAll(){
    computeStep1();
    computeStep2();
    computeStep3();
  }
  void method1(){
    computeAll();
  }
  void method2(){
    computeAll();
  }
  …
}
```

Method refactoring limitations

- Method refactoring is the easiest but has several limitations
  - Only effective when common code is contained in a single method, can become much more difficult when spread across multiple functions
  - Only possible when duplicate code is all within the same class

Refactoring across classes

- Commonalities in code across classes has several complications
  - Similar/duplicate code may refer to variables that are not accessible by other duplicate code
  - Strongly tying code together due to similarity of a function alone violates encapsulation
- Solution → refactoring by inheritance or delegation

Refactoring by inheritance

- If duplicate code appears across two different classes may be able to refactor by inheritance
- Common code pulled into either shared parent class or new parent class created
- Any variables used also pulled to parent class

inheritance refactoring

```
class Computation1{
  void method1(){
    computeStep1();
    computeStep2();
    computeStep3();
  }
}
class Computation2{
  void method2(){
    computeStep1();
    computeStep2();
    computeStep3();
  }
```

```
class Computation{
  void computeAll(){
    computeStep1();
    computeStep2();
    computeStep3();
  }
class Computation1 extends
          Computation {
  void method1(){
    computeAll();
  }
}
class Computation2 extends
          Computation {
  void method2(){
    computeAll();
  }
  …
}
```

Refactoring by inheritance limitations

- Creates problems if the two classes are not related enough to justify inheriting from same class
- Due to limitation of single inheritance, if either class has a different parent its not possible to move code to parent

Refactoring by delegation

- Duplicate code pulled to different class and implementation of the common code is *delegated* to this class
- Requires original classes to have a reference to the delegated class
- Any non-visible variables need to be passed into helper class

delegation refactoring

```
class Computation1{
  void method1(){
    computeStep1();
    computeStep2();
    computeStep3();
  }
}
class Computation2{
  void method2(){
    computeStep1();
    computeStep2();
    computeStep3();
  }
  …
```

```
class Helper{
  void computeAll(int length){
    computeStep1(length);
    computeStep2();
    computeStep3();
  }
class Computation1{
  Helper myHelper = new Helper();
  void method1(){
    myHelper.computeAll(this.length);
  }
}
class Computation2 {
  Helper myHelper = new Helper();
  void method2(){
    myHelper.computeAll(this.length);
  }
  …
}
```

Refactoring decisions

- Refactoring by delegation can always be used and has the advantage of not putting inheritance restrictions (ie. Avoid problem with single inheritance limitation)
- Refactoring by delegation is most complex and most difficult to understand through reading the code. Therefore its often preferable to use refactoring by inheritance

Maximizing extensibility

- When code is refactored the goal is to better the chance the code can be reused
- One way this is done is making the code extensible
  - Allow calling component to alter context the code runs in
  - Extend functionality through making changes to parameters of execution

Extensibility

- Changing the parameters of execution
  - Allow calling component to set context of super class or helper class through accessors
    - Ex. setNumberOfSidesShape
  - Allow calling component to pass in parameters of execution
    - Ex. drawShape(color)

Inheritance complications

- Complications arise when duplicate code but different detailed implementations
- Ex.
-

```
public class Computation1
// this portion of Computation1 and
// Computation 2 are identical
void compute(){
  computeA();
  computeB();  // implementation differs
  computeC();
}
```

Extensibility of methods

- Duplicate code may make same function calls but be implemented differently
- Extensibility can also be applied to methods
  - Option 1: Provide a default implementation of method in super class, which can then be overridden
  - Option 2: If no default implementation make super class abstract and the method in question

Extensible methods ex.

```
public abstract class Shape{
  public void computeAll(){
    calculatePerimeter();
    calculateArea();
  }
  public void calculatePerimeter(){
    // add all sides
  }
  abstract public void calculateArea();
}
public class square extends Shape{
  public void calculate(){
    …
    computeAll();
  }
  public void calculateArea(){ area = side * side;}
}
public class circle extends Shape{
  public void calcValue(){
    …
    computeAll();
  }
  pubic void calculatePerimeter(){ perim = 2*pi*r;}
  public void calculateArea(){ area = pi * r^2;}
}
```

Preventing misuse

- When extracting duplicate code to super class there are times when some portion of the duplicate code should not be overridden while some portion could be
  - Ex. initialization
- Solution is to introduce methods aimed at extensibility while limiting misuse
- Code that should not be overridden would then be marked `final`

Avoiding misuse example

```
public abstract class Shape{
  public void drawShape(){
    init();
    initShapeImplementation();
    getCenter();
    getPerimeter();
    drawShape();
  }
  final public void init(){
    // initialize drawing canvas
  }
  abstract public void initShapeImplementation(){}
}
public class Square extends Shape{
  public void changeSize(){
    …
    drawShape();
  }
  public void initShapeImplementation(){
    // initialize shape specific drawing features
  }
}
```

Complications with delegation

- Complications arise when duplicate code but different detailed implementations
- Ex.

```
public class Helper
 // this portion of Computation1 and
// Computation 2 are identical
void compute(){
  computeA();
  computeB();  // implementation differs
  computeC();
}
```

Complications with delegation

- With inheritance refactoring different implementations of the same method pose little problem
- Method with common code simply calls parent method or abstract method
- With delegation refactoring different implementations are more complex
- Implementation of individual methods is not extracted

Delegation solution

- With delegation, in order to support different implementations the calling class needs to pass itself to the Helper class
- Helper class then calls the method on the passed in object
- Because different objects do not have the same parent class (otherwise inheritance refactoring would have been used) implementing a common interface is needed

Delegation example

```
public class Helper{
  public void computeAll(ShapeComputer passedInstance){
    computeA();
    passedInstance.computeB();
    computeC();
  }
}
public interface ShapeComputer{
  public void computeB();
}
public class square implements ShapeComputer{
  public void calculate(){
    …
    computeAll();
  }
  public void computeB(){ area = side * side;}
}
public class circle implements ShapeComputer{
  public void calcValue(){
    …
    computeAll();
  }
  public void computeB(){ area = pi * r^2;}
}
```

- Result is delegation is more likely to become complex than inheritance refactoring