Introduction to Refactoring

Refactoring

- Refactoring is:
  - restructuring (rearranging) code in a series of small, semantics-preserving transformations (i.e. the code keeps working) in order to make the code easier to maintain and modify
- Refactoring is not just arbitrary restructuring
  - Code must still work
  - Small steps only so the semantics are preserved (i.e. not a major re-write)
  - Unit tests to prove the code still works
  - Code is
    - More loosely coupled
    - More cohesive modules
    - More comprehensible
- There are numerous well-known refactoring techniques
  - You should be at least somewhat familiar with these before inventing your own
  - Refactoring “catalog”

When to refactor

- You should refactor:
  - Any time that you see a better way to do things
    - “Better” means making the code easier to understand and to modify in the future
  - You can do so without breaking the code
    - Unit tests are essential for this
- You should not refactor:
  - Stable code that won’t need to change
  - Someone else’s code
    - Unless the other person agrees to it or it belongs to you
    - Not an issue in Agile Programming since code is communal

Back to refactoring

- When should you refactor?
  - Any time you find that you can improve the design of existing code
  - You detect a “bad smell” (an indication that something is wrong) in the code
- When can you refactor?
  - You should be in a supportive environment (agile programming team, or doing your own work)
  - You are familiar with common refactorings
  - Refactoring tools also help
  - You should have an adequate set of unit tests

Refactoring Process

- Make a small change
  - a single refactoring
- Run all the tests to ensure everything still works
- If everything works, move on to the next refactoring
- If not, fix the problem, or undo the change, so you still have a working system

Code Smells

- If it stinks, change it
  - Code that can make the design harder to change
- Examples:
  - Duplicate code
  - Long methods
  - Big classes
  - Big switch statements
  - Long navigations (e.g., a.b().c().d())
  - Lots of checking for null objects
  - Data clumps (e.g., a Contact class that has fields for address, phone, email etc.) - similar to non-normalized tables in relational design
  - Data classes (classes that have mainly fields/properties and little or no methods)
  - Un-encapsulated fields (public member variables)

- Divergent change
- Shotgun surgery
- Lazy class
- Speculative generality
- Feature envy
- Refused Bequest
- Comments

Refactoring Techniques

Example 1: switch statements

- switch statements are very rare in properly designed object-oriented code
  - Therefore, a switch statement is a simple and easily detected “bad smell”
  - Of course, not all uses of switch are bad
  - A switch statement should *not* be used to distinguish between various kinds of object
- There are several well-defined refactorings for this case
  - The simplest is the creation of subclasses

Example 1, continued

```
class Animal {
   final int MAMMAL = 0, BIRD = 1, REPTILE = 2;
   int myKind;  // set in constructor
   ...
   String getSkin() {
      switch (myKind) {
         case MAMMAL: return "hair";
         case BIRD: return "feathers";
         case REPTILE: return "scales";
         default: return “skin";
      }
   }
}
```

Example 1, improved

```
class Animal {
    String getSkin() { return “skin"; }
}
class Mammal extends Animal {
    String getSkin() { return "hair"; }
}
class Bird extends Animal {
    String getSkin() { return "feathers"; }
}
class Reptile extends Animal {
    String getSkin() { return "scales"; }
}
```

How is this an improvement?

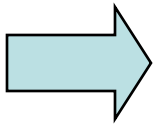
- Adding a new animal type, such as Amphibian, does not require revising and recompiling existing code
- Mammals, birds, and reptiles are likely to differ in other ways, and we've already separated them out (so we won't need more switch statements)
- We've gotten rid of the flags we needed to tell one kind of animal from another
- We're now using Objects the way they were meant to be used

Example 2: Encapsulate Field

- Un-encapsulated data is a no-no in OO application design. Use property get and set procedures to provide public access to private (encapsulated) member variables.

```
public class Course
{
 public List students;

}
```

```
int classSize = course.students.size();
```



```
public class Course
{
 private List students;
 public List getStudents()
 {
    return students;
 }
 public void setStudents(List s)
 {
     students = s;
  }
}
```

```
int classSize = course.getStudents().size();
```

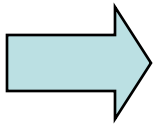
Encapsulating Fields

- I have a class with 10 fields. This is a pain to set up for each one.
- Refactoring Tools
  - See NetBeans/Visual Studio refactoring examples
  - Also:
    - Rename Method
    - Change Method Parameters

3. Extract Class

- Break one class into two, e.g. Having the phone details as part of the Customer class is not a realistic OO model, and also breaks the Single Responsibility design principle. We can refactor this into two separate classes, each with the appropriate responsibility.

```
public class Customer
{
 private String name;
 private String workPhoneAreaCode;
 private String workPhoneNumber;
}
```

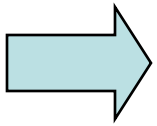


```
public class Customer
{
private String name;
private Phone workPhone;
}

public class Phone
{
private String areaCode;
private String number;
}
```

4. Extract Interface

- Extract an interface from a class. Some clients may need to know a Customer's name, while others may only need to know that certain objects can be serialized to XML. Having toXml() as part of the Customer interface breaks the Interface Segregation design principle which tells us that it's better to have more specialized interfaces than to have one multi-purpose interface.

```
public class Customer
{
private String name;

public String getName(){ return name; }

public void setName(String string)
{ name = string; }

public String toXML()
{ return "<Customer><Name>" +
 name + "</Name></Customer>";
 }
}
```



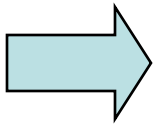
```
public class Customer implements SerXML
{
private String name;

public String getName(){ return name; }

public void setName(String string)
{ name = string; }

public String toXML()
{ return "<Customer><Name>" +
 name + "</Name></Customer>";
 }
}
```

```
public interface SerXml {
   public abstract String toXML();
}
```

5. Extract Method

- Sometimes we have methods that do too much. The more code in a single method, the harder it is to understand and get right. It also means that logic embedded in that method cannot be reused elsewhere. The Extract Method refactoring is one of the most useful for reducing the amount of duplication in code.

```
public class Customer
{
  void int foo()
  {
     …
     // Compute score
    score = a*b+c;
    score *= xfactor;
  }
}
```

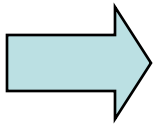


```
public class Customer
{
  void int foo()
  {
     …
    score = ComputeScore(a,b,c,xfactor);
  }

  int ComputeScore(int a, int b, int c, int x)
  {
     return (a*b+c)*x;
  }
}
```

6. Extract Subclass

- When a class has features (attributes and methods) that would only be useful in specialized instances, we can create a specialization of that class and give it those features. This makes the original class less specialized (i.e., more abstract), and good design is about binding to abstractions wherever possible.

```
public class Person
{
 private String name;
 private String jobTitle;
}
```

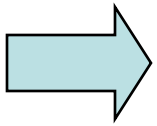


```
public class Person
{
 protected String name;
}

public class Employee extends Person
{
 private String jobTitle;
}
```

7. Extract Super Class

- When you find two or more classes that share common features, consider abstracting those shared features into a super-class. Again, this makes it easier to bind clients to an abstraction, and removes duplicate code from the original classes.

```
public class Employee
{
  private String name;
  private String jobTitle;
}

public class Student
{
  private String name;
  private Course course;
}
```



```
public abstract class Person
{
  protected String name;
}

public class Employee extends Person
{
  private String jobTitle;
}

public class Student extends Person
{
  private Course course;
}
```

8. Form Template Method - Before

- When you find two methods in subclasses that perform the same steps, but do different things in each step, create methods for those steps with the same signature and move the original method into the base class

```
public abstract class Party { }
```

```
public class Person extends Party
{
 private String firstName;
 private String lastName;
 private Date dob;
 private String nationality;
 public void printNameAndDetails()
 {
   System.out.println("Name: " + firstName + " " + lastName);
   System.out.println("DOB: " + dob.toString() + ", Nationality: " + nationality);
  }
}
```

```
public class Company extends Party
{
  private String name;
  private String companyType;
  private Date incorporated;
  public void PrintNameAndDetails()
  {
   System.out.println("Name: " + name + " " + companyType);
   System.out.println("Incorporated: " + incorporated.toString());
  }
}
```

Form Template Method - Refactored

```
public abstract class Party
{
 public void PrintNameAndDetails()
 {
   printName();
   printDetails();
 }
 public abstract void printName();
 public abstract void printDetails();
}

public class Person extends Party
{
  private String firstName;
  private String lastName;
  private Date dob;
  private String nationality;
  public void printDetails()
  {
    System.out.println("DOB: " + dob.toString() + ", Nationality: " + nationality);
  }
  public void printName()
  {
    System.out.println("Name: " + firstName + " " + lastName);
  }
}
```

```
public class Company extends Party
{
  private String name;
  private String companyType;
  private Date incorporated;
  public void printDetails()
  {
    System.out.println("Incorporated: " + incorporated.toString());
  }
  public void printName()
  {
    System.out.println("Name: " + name + " " + companyType);
  }
}
```

9. Move Method - Before

- If a method on one class uses (or is used by) another class more than the class on which its defined, move it to the other class

```
public class Student
{
  public boolean isTaking(Course course)
  {
     return (course.getStudents().contains(this));
   }
}

public class Course
{
  private List students;
  public List getStudents()
  {
    return students;
  }
}
```

Move Method - Refactored

- The student class now no longer needs to know about the Course interface, and the isTaking() method is closer to the data on which it relies - making the design of Course more cohesive and the overall design more loosely coupled

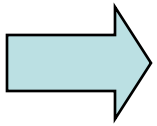
```
public class Student
{
}

public class Course
{
  private List students;
  public boolean isTaking(Student student)
  {
     return students.contains(student);
  }
}
```

10. Introduce Null Object

- If relying on null for default behavior, use inheritance instead

```
public class User
{
  Plan getPlan()
  {
      return plan;
  }
}
```

```
if (user == null)
    plan = Plan.basic();
else
   plan = user.getPlan();
```

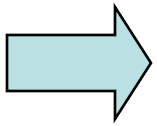


```
public class User
{
  Plan getPlan()
  {
    return plan;
  }
}

public class NullUser extends User
{
  Plan getPlan()
  {
     return Plan.basic();
  }
}
```

11. Replace Error Code with Exception

- A method returns a special code to indicate an error is better accomplished with an Exception.

```
int withdraw(int amount)
{
  if (amount > balance)
                return -1;
  else {
                balance -= amount;
                return 0;
        }
}
```

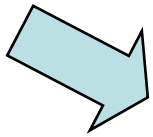


```
void withdraw(int amount)
   throws BalanceException
{
  if (amount > balance)
  {
                throw new BalanceException();
   }
  balance -= amount;
}
```

12. Replace Exception with Test

- Conversely, if you are catching an exception that could be handled by an if-statement, use that instead.

```
double getValueForPeriod (int periodNumber)
 {
  try
  {
     return values[periodNumber];
  }
  catch (ArrayIndexOutOfBoundsException e)
  {
    return 0;
  }
}
```



```
double getValueForPeriod (int periodNumber)
 {
   if (periodNumber >= values.length) return 0;
   return values[periodNumber];
 }
```

13. Nested Conditional with Guard

- A method has conditional behavior that does not make clear what the normal path of execution is. Use Guard Clauses for all the special cases.

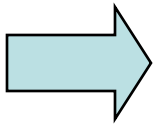
```
double getPayAmount() {
  double result;
  if (isDead) result = deadAmount();
  else {
                if (isSeparated) result = separatedAmount();
                else {
                                if (isRetired) result = retiredAmount();
                                else result = normalPayAmount();
                }
  }
  return result;
}
```

```
double getPayAmount() {
                if (isDead) return deadAmount();
                if (isSeparated) return separatedAmount();
                if (isRetired) return retiredAmount();
                return normalPayAmount();
};
```

14. Replace Parameter with Explicit Method

- You have a method that runs different code depending on the values of an enumerated parameter. Create a separate method for each value of the parameter.

```
void setValue (String name, int value) {
  if (name.equals("height")) {
   height = value;
   return;
  }
  if (name.equals("width")) {
    width = value;
    return;
  }
  Assert.shouldNeverReachHere();
}
```



```
void setHeight(int arg)
{
    height = arg;
}

void setWidth (int arg)
{
    width = arg;
}
```

15. Replace Temp with Query

- You are using a temporary variable to hold the result of an expression. Extract the expression into a method. Replace all references to the temp with the expression. The new method can then be used in other methods and allows for other refactorings.

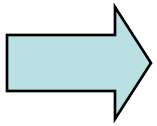
```
double basePrice = quantity * itemPrice;
if (basePrice > 1000)
        return basePrice * 0.95;
else
        return basePrice * 0.98;
```

```
if (basePrice() > 1000)
        return basePrice() * 0.95;
else
        return basePrice() * 0.98;
...
double basePrice() {
        return quantity * itemPrice;
}
```

16. Rename Variable or Method

- Perhaps one of the simplest, but one of the most useful that bears repeating: If the name of a method or variable does not reveal its purpose then change the name of the method or variable.

```
public class Customer
{
   public double getinvcdtlmt();
}
```



```
public class Customer
{
   public double getInvoiceCreditLimit();
}
```

Code Smells and Possible Refactoring

Duplicated Code

- Extract Method
- Pull up method
- Substitute algorithm
- Extract Classes

Long Method

- Extract Method

Large Class

- Too many variables or too many methods
- -extract class
- Extract subclass
- Extract interface

Divergent Change

- If you find yourself repeatedly changing the same class for different requirements
  - extract class- group functionality commonly changed into a class.

Shotgun Surgery

- If you find yourself making a lot of small changes for each desired change.
  - Move method/fields :- pull all the changes into a single class.
  - Inline Class:- group a bunch of behaviours together in an existing class.

Lazy Class

- class does not do much
  - Eliminate it
  - Collapse Hierarchy

Speculative Generality

- “I think we need this kind of functionality in some day”
- remove the things which is not using because result often harder to understand and maintiain.
  - Collapse Hierarchy for abstract class
  - Remove unused parameters.
  - Remove unused methods

Data Class

- These are classes that have fields,.getting and setting methods for the fields and nothing else.
  - Encapsulation-if public fileds.
  - Remove setting methods for final variables.
  - Look for methods which use these variables and move to data class .

Feature Envy

- Methods making more use of another class than the one it is in.
  - Move method
  - Move field
  - Extract method

Refused Bequest

- A class doesn’t use things it inherits from its superclass.
  - Push Down method/fileds.
  - Remove inheitance.
  - Get rid of wrong hierarchy.

Comments

- Comments are often a sign of unclear code, so consider refactoring.
  - Extract method
  - Rename method/field

More on Refactorings

- Refactoring Catalog
  - http://www.refactoring.com/catalog
- Java Refactoring Tools
  - NetBeans 4+ – Built In
  - JFactor – works with VisualAge and JBuilder
  - RefactorIt – plug-in tool for NetBeans, Forte, JBuilder and JDeveloper. Also works standalone.
  - JRefactory – for jEdit, NetBeans, JBuilder or standalone
- Visual Studio 2005+
  - Refactoring Built In
    - Encapsulate Field, Extract Method, Extract Interface, Reorder Parameters, Remove Parameter, Promote Local Var to Parameter, more.