Refactoring

Definition

“A change made to the internal structure of software to make it easier to understand and cheaper to modify without changing its observable behavior,” M. Fowler, K. Beck et al.

Refactoring doesn’t mean adding new features

Intro.

- **Definition:** Refactoring is a disciplined technique for restructuring an existing body of code, altering its internal structure without changing its external behavior.

- Refactoring does not fix bugs, but it may help find bugs by scrutinizing code. It may also reduce the further introduction of bugs by cleaning-up code.

- Refactoring does not add new functionality to the system, but it will ease the further adding of new functionality.

- It is an essential part of agile software development such as Extreme Programming or incremental development.

Why can’t you write clean code within the current budget and timeline?

- **Unclear requirements**
- **Time constraints -** The fast solution is more valuable than flawless one.
- **Different experience and coding styles -** The project team is usually composed of developers with varying levels of experience.

How do I know if my product needs refactoring?

- Polishing the code in advance is usually a bad decision.
- Bryan Helmkamp at Code Climate

  - **Refactoring speeds up the current task**

  - It is quick and easy - if there is a quick change

  - The three strikes rule if a certain code snippet causes your team trouble three times, it is time to put some work into making it simpler.

Code Smells

- **Symptoms of inferior code quality that can contribute to technical debt.**
- 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)

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?

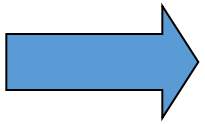
- Adding a new animal type, such as Amphibian, does not require revising and recompiling existing code
- Mammals, birds, and reptiles are likely to differ in other ways, and we've already separated them out (so we won't need more switch statements)
- We've gotten rid of the flags we needed to tell one 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();
```

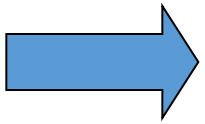
Encapsulating Fields

- 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;
}
```

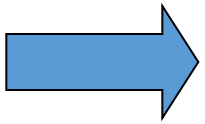


```
public class Customer
{
private String name;
private Phone workPhone;
}

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>";
 }
}
```



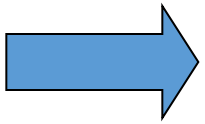
```
public class Customer implements SerXML
{
private String name;

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;
  }
}
```

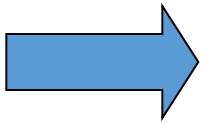


```
public class Customer
{
  void int foo()
  {
     …
     score = ComputeScore(a,b,c,xfactor);
  }

  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;
}
```

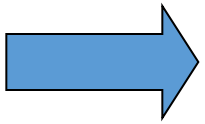


```
public class Person
{
 protected String name;
}

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

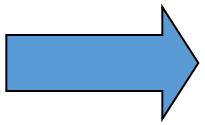
```
public class Student
{
}

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();
```

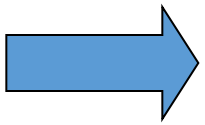


```
public class User
{
  Plan getPlan()
  {
    return plan;
  }
}

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;
        }
}
```

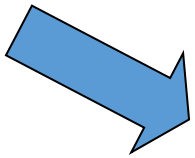


```
void withdraw(int amount)
   throws BalanceException
{
  if (amount > balance)
  {
          throw new BalanceException();
   }
  balance -= amount;
}
```

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.

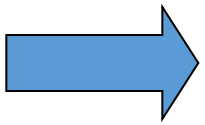
```
double getPayAmount() {
  double result;
  if (isDead) result = deadAmount();
  else {
        if (isSeparated) result = separatedAmount();
        else {
              if (isRetired) result = retiredAmount();
              else result = normalPayAmount();
        }
  }
  return result;
}
```

```
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.

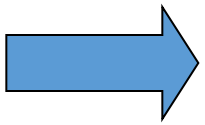
```
        double basePrice = quantity * itemPrice;
        if (basePrice > 1000)
            return basePrice * 0.95;
        else
            return basePrice * 0.98;
```

```
        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();
}
```

Refactoring: why?

- Refactoring is usually done to:
  - Improve quality
    - improve design quality
    - improve maintainability
    - improve extensibility
    - Improve sustainability of development
    - requires proper testing, so improves testability
    - helps to find bugs
  - Improve productivity
    - improve code readability & comprehensibility
    - simplify code structure

Refactoring: drawbacks

- **Cost Overhead:** Refactoring is an add-on activity and therefore will incur extra cost in form of time, effort, and resource allocation, especially if elaborated design and code documentation is maintained. However, when done sparingly and only on key issues, its benefits are greater than its overhead. Automated documentation tools, code browsing tools, refactoring tools and testing tools will also diminish the refactoring overhead.

- **Requires Expertise:** Refactoring requires some expertise and experience and considerable effort in going through the process, especially if proper testing is involved. However, this overhead can be minimized by using refactoring tools and automated testing such as with a unit testing framework.