Patterns and Refactoring

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Patterns

What is a Pattern?

A pattern addresses a recurring problem that arises in specific situations.

Patterns document existing, well-proven design experience.

Patterns identify and specify abstractions that are above the level of single classes and instances.

What is a Pattern ?

Patterns provide a common vocabulary and understanding for design principles.
Patterns are a means of documenting software architectures.
Patterns support the construction of software with defined properties.
Patterns help you build complex and heterogeneous software architectures.
Patterns help you manage software complexity.

Types of Patterns

Design Patterns
Analysis patterns
Software architecture patterns
Process patterns
Organizational patterns
...

Design Patterns

Design patterns provide **abstract, reusable "micro-architectures"** that can be applied ("instantiated") to resolve specific design issues (forces) in previously-used, high-quality ways

GoF (Gang of Four – Gamma, Helm, Johnson, Vlissides) defined widely used 23 design patterns like Factory, Observer, Visitor, State, Strategy etc.

Analysis Patterns

By Martin Fowler :

Patterns that reflect **conceptual structures** of business processes rather than actual software implementations.

Fowler uses a simple, specialized notation (very similar to entity-relationship diagram notation) to depict graphical models of analysis patterns.

Software Architecture Patterns

Architectural patterns are templates for **concrete** software architectures. They specify the system-wide structural properties of an application, and have an impact on the architecture of its subsystems.

Other Pattern Types

Process Patterns

- patterns that deal with software development **process issues**
- work by Scott Ambler

Organizational Patterns

- patterns that deal with **organizational issues** that arise in software development teams, groups and departments
- these can often be related to software process patterns

Other Pattern Types

Pedagogical Patterns

patterns that deal with best practice solutions to software technology education and training (object-oriented software development in particular)

see work by Mary Lynn Manns et al.

http://www-lifia.info.unlp.edu.ar/ppp/

Potential benefits of Patterns

Provides a common **vocabulary** and **understanding** of design elements for software designers

Increases **productivity** in design process due to “design reuse”

Promotes **consistency** and high quality of system designs and architectures due to application of tested design expertise and solutions embodied by patterns

Benefits of Patterns

allows all levels of designers, from novice to expert, to gain these productivity, quality and consistency benefits

Concerns

Training and education in common and proprietary patterns

- benefits are dependent upon architects, analysts and designers understanding the patterns to be used
- benefits are enhanced significantly only if ALL software development personnel understand the patterns as a common "design vocabulary"
- such training can be costly, and in many cases is proprietary and cannot be obtained externally

Concerns

Evolution and maintenance to insure continued value

- specific funding and effort must be directed toward maintenance and evolution of patterns as reusable assets or they tend to devolve into project/application-specific artifacts with dramatically reduced reusability characteristics
- the necessary funding, technical or organizational infrastructure supports may not exist to allow effective maintenance and evolution of patterns within an organization to insure continued high benefits

AntiPatterns (from Brown, et al.)

An AntiPattern is a literary form that describes a commonly occurring solution to a problem that generates decidedly negative consequences.

Primal Forces

AntiPatterns, like other patterns, deal with forces (concerns, issues) that exist in a specific problem setting

Vertical forces are problem domain-specific

Horizontal forces are applicable across multiple domains or problem settings

Primal Forces

Primal Forces are horizontal forces that are pervasive in software architecture and development. They include:

- Management of functionality: meeting the requirements
- Management of performance: meeting required speed of operation
- Management of complexity: defining abstractions
- Management of change: controlling the evolution of software
- Management of IT resources: controlling the use and implementation of people and IT artifacts
- Management of technology transfer: controlling technology change

Refactoring

A disciplined approach to rework for better design

Refactoring: duplicated code

```
case 0:
    activePiece = RightHook.getRightHook();
    ml = new MoveListener(activePiece);
    gameBoard.addKeyListener(ml);
    break;
case 1:
    activePiece = LeftHook.getLeftHook();
    ml = new MoveListener(activePiece);
    gameBoard.addKeyListener(ml);
    break;
case 2:
    activePiece = RightRise.getRightRise();
    ml = new MoveListener(activePiece);
    gameBoard.addKeyListener(ml);
    break;
case 3:
    activePiece = LeftRise.getLeftRise();
    ml = new MoveListener(activePiece);
    gameBoard.addKeyListener(ml);
    break;  //more
```

Source: Daniel H Steinberg

Refactoring: duplicated code

```
case 4:
    activePiece = Hill.getHill();
    ml = new MoveListener(activePiece);
    gameBoard.addKeyListener(ml);
    break;
case 5:
    activePiece = StraightPiece.getStraightPiece();
    ml = new MoveListener(activePiece);
    gameBoard.addKeyListener(ml);
    break;
case 6:
    activePiece = Square.getSquare();
    ml = new MoveListener(activePiece);
    gameBoard.addKeyListener(ml);
    break; //...
```

Source: Daniel H Steinberg

Refactoring: duplicated code

```
case 0:
    activePiece = RightHook.getRightHook();          break;
case 1:
    activePiece = LeftHook.getLeftHook();            break;
case 2:
    activePiece = RightRise.getRightRise();          break;
case 3:
    activePiece = LeftRise.getLeftRise();            break;
case 4:
    activePiece = Hill.getHill();                    break;
case 5:
    activePiece = StraightPiece.getStraightPiece();  break;
case 6:
    activePiece = Square.getSquare();                break;
}
  ml = new MoveListener(activePiece);
  gameBoard.addKeyListener(ml);
```

Source: Daniel H Steinberg

Could create an array

```
case 0:
    activePiece = RightHook.getRightHook();        break;
case 1:
    activePiece
case 2:
    activePiece
case 3:
    activePiece
case 4:
    activePiece = Hill.getHill();                  break;
case 5:
    activePiece = StraightPiece.getStraightPiece();   break;
case 6:
    activePiece = Square.getSquare();              break;
}
   ml = new MoveListener(activePiece);
   gameBoard.addKeyListener(ml);
```

```
Piece [] pieceList = {RightHook.getRightHook(),
  LeftHook.GetLeftHook(), RightRise.getRightRise(),
  LeftRise.getLeftRise(), Hill.getHill(),
  StraightPiece.getStraightPiece(), Square.getSquare()};
```

Source: Daniel H Steinberg

Now your switch statement becomes

```
case 0:
    activePiece = RightHook.getRightHook();        break;
case 1:
    activePiece = LeftHook.getLeftHook();          break;
case 2:
    activePiece = Ri
case 3:
    activePiece = Le
case 4:
    activePiece = Hi
case 5:
    activePiece = St
case 6:
    activePiece = Square.getSquare();              break;
}
  ml = new MoveListener(activePiece);
  gameBoard.addKeyListener(ml);
```

```
public void letsRoll(){
  activePiece =
    pieceList[(int)(Math.random()*7)]
  ml = new MoveListener(activePiece);
  gameBoard.addKeyListener(ml);
}
```

Source: Daniel H Steinberg

Introduce a new method

```
public void letsRoll(){
  activePiece = pieceList[(int)(Math.random()*7)]
  ml = new MoveListener(activePiece);
  gameBoard.addKeyListener(ml);
}
```

Source: Daniel H Steinberg

```
public void letsRoll(){
  activePiece = selectNextActivePiece();
  ml = new MoveListener(activePiece);
  gameBoard.addKeyListener(ml);
}
private Piece selectNextActivePiece(){
  return pieceList[(int) Math.random()*7)];
}
```

Introduce a new method

We don't need to create a new Move Listener...(and what's ml?)

```
public void letsRoll(){
  activePiece = selectNextActivePiece();
  ml = new MoveListener(activePiece);
  gameBoard.addKeyListener(ml);
}
private Piece selectNextActivePiece(){
  return pieceList[(int) Math.random()*7)];
}
```

Source: Daniel H Steinberg

Introduce a new method

We don't need to create a new Move Listener...(and what's ml?)

```
public void letsRoll(){
  activePiece = selectNextActivePiece();
  ml = new MoveListener(activePiece);
  gameBoard.addKeyListener(ml);
}
private Piece selectNextActivePie
  return pieceList[(int) Math.rand
}
```

```
public void letsRoll(){
  activePiece = selectNextActivePiece();
  moveListener.setActivePiece(activePiece);
}

private Piece selectNextActivePiece(){
  return pieceList[(int) Math.random()*7)];
}
```

Source: Daniel H Steinberg

Eliminate the variable activePiece

```
public void letsRoll(){
  activePiece = selectNextActivePiece();
  moveListener.setActivePiece(activePiece);
}

private Piece selectNextActive
  return pieceList[(int) Math.r
}
```

```
public void letsRoll(){
  moveListener.setActivePiece(
                    selectNextActivePiece() );
}

private Piece selectNextActivePiece(){
  return pieceList[(int) Math.random()*7)];
}
```

Source: Daniel H Steinberg

Accountability

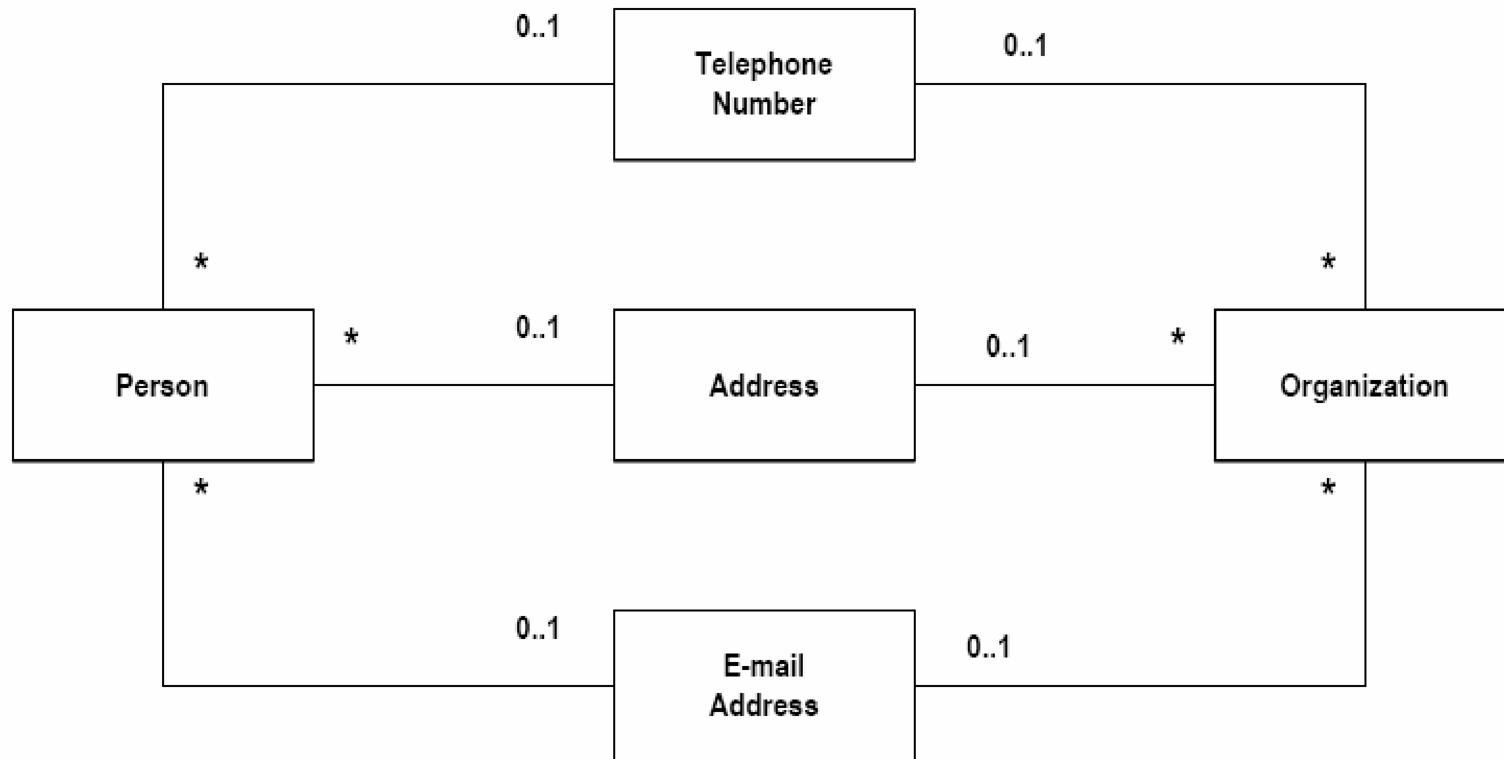
A relationship of responsibility between responsee and responsible

Organizational structures

Employments

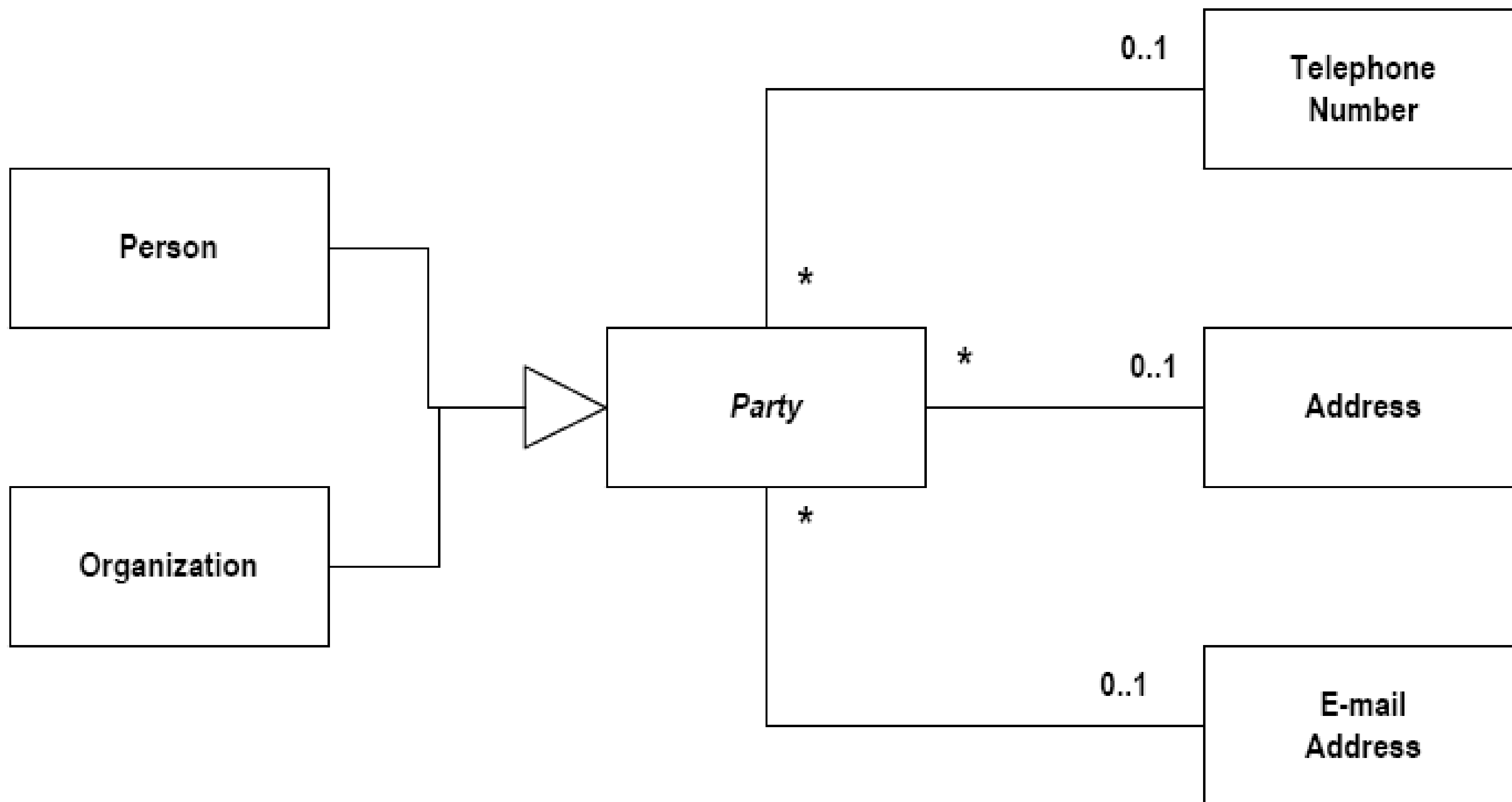
Contracts

Address Book



Analysis Patterns book: Martin Fowler

Party



Analysis Patterns book: Martin Fowler

Refactoring

Martin Fowler (and Kent Beck, John Brant, William Opdyke, Don Roberts), *Refactoring- Improving the Design of Existing Code*, Addison Wesley, 1999.

Refactoring (noun):

a change made to the internal structure of software to make it easier to understand and cheaper to modify without changing its observable behavior.

Refactor (verb):

to restructure software by applying a series of refactorings.

Why should refactoring be done?

Argument 1
Refactoring **Improves the Design** of Software.
Without refactoring, the design of the program will decay. As people change code - changes to realize short-term goals or changes made without a full comprehension of the design of the code - the code loses its structure.

When should refactoring be done?

Argument 2
Refactoring makes software **easier to understand.**
There are users of your code. The computer, the writer, and the updater. The most important is the updater. Who cares if the compiler takes a few more cycles to compile your code. If it takes someone 3 weeks to update your code that is a problem.

Who should be doing refactoring?

Argument 3
Refactoring helps you **find bugs**.
Part of refactoring code is understanding the code and putting that understanding back into the code. In that process a clarification takes place. In that clarification bugs will be found.

Who should be doing refactoring?

Argument 4
Refactoring Helps you **Program Faster**.
Without a good design, you can progress quickly for a while, but soon poor design start to slow you down. You spend time finding and fixing bugs and understanding the system instead of adding new function. New features need more coding as you patch over a patches...

Bad smells

Knowing how to refactor something does not tell you when to refactor and how much to refactor.

Kent Beck and Martin Fowler coined a phrase ‘Bad Smells’ to describe the hint of when to refactor.

This phrase was meant to reflect the ability and experience gained over time by a programmer that is needed to recognize bad coding structure.

Bad Smell Examples

- Duplicate Code
- Long Methods
- Large Classes
- Long Parameter Lists
- Feature Envy
- Data Clumps

Bad smells: Duplicated code

"The #1 bad smell"

Same expression in two methods in the same class?

Make it a private ancillary routine and parameterize it - gather duplicated code (Extract method)

Same code in two related classes?

- Push commonalities into closest mutual ancestor and parameterize
- Use template method DP for variation in subtasks - gather similar parts, leaving holes (Form template method)

Bad smells: Duplicated code

Same code in two unrelated classes?

- Ought they be related?
  - Introduce abstract parent (Extract class, Pull up method)
- Does the code really belongs to just one class?
  - Make the other class into a client (Extract method)

Bad smells: Long method

Often a sign of:

Trying to do too many things

Poorly thought out abstractions and boundaries

Best to think carefully about the major tasks and how they inter-relate.

Break up into smaller private methods within the class (Extract method)

Delegate subtasks to subobjects that "know best" (i.e., template method DP)
(Extract class/method, Replace data value with object)

Bad smells in code: Long method

Fowler's heuristic:

- When you see a comment, make a method.
- Often, a comment indicates:
  - The next major step
  - Something non-obvious whose details detract from the clarity of the routine as a whole.
- In either case, this is a good spot to "break it up".

Bad smells: Feature envy

A method seems more interested in another class than the one it's defined in e.g., a method
A::m() calls lots of get/set methods of class B

Solution:

Move m() (or part of it) into B!

(Move method/field, extract method)

Exceptions:

Visitor/iterator/strategy DP where the whole point is to decouple the data from the algorithm
Feature envy is more of an issue when both A and B have interesting data

Bad smells: Data clumps

You see a set of variables that seem to "hang out" together

e.g., passed as parameters, changed/accessed at the same time

Usually, this means that there's a coherent subobject just waiting to be recognized and encapsulated

```
void Scene::setTitle (string titleText,
            int titleX, int titleY,
            Colour titleColour){…}

void Scene::getTitle (string& titleText,
            int& titleX, int& titleY,
            Colour& titleColour){…}
```

Bad smells: Data clumps

In the example, a Title class is dying to be born

If a client knows how to change a title's x, y, text, and colour, then it knows enough to be able to "roll its own" Title objects.

However, this does mean that the client now has to talk to another class.

This will greatly shorten and simplify your parameter lists (which aids understanding) and makes your class conceptually simpler too.

Moving the data may create feature envy initially

Bad smells: Primitive obsession

All subparts of an object are instances of primitive types

- (int, string, bool, double, etc.)
  e.g., dates, currency, SIN, tel.#, ISBN, special string values

Often, these small objects have interesting and non-trivial constraints that can be modelled

- e.g., fixed number of digits/chars, check digits, special values

Solution:

- Create some "small classes" that can validate and enforce the constraints. This makes your system more strongly typed.

Why not refactor?

Conventional wisdom would discourage

modifying a design

- You might break something in the code
- You have to update the documentation
- Both expensive

But, there are longer term concerns: sticking with an inappropriate design

- Makes the code harder to change
- Makes the code harder to understand and maintain
- Very expensive in the long run

Refactoring Philosophy

Make all changes small and methodical

- Follow design patterns

Retest the system after each change

- By rerunning all of your unit tests
- If something breaks, it's easy to see what caused the failure

Principles of Refactoring

In general, each refactoring aims to

- decompose large objects into smaller ones
- distribute responsibility

Like design patterns

- Adds composition and delegation
- In some sense, refactorings are ways of applying design patterns to existing code

Obstacles to Refactoring

Complexity

Changing design is hard, understanding code is hard

Possibility to introduce errors

Mitigated by testing

Clean first Then add new functionality

Cultural Issues

Producing negative lines of code, what an idea!

We pay you to add new features, not to improve the code!

If it ain t broke, don't fix it

We do not have a problem, this is our software!

RefactorIT - www.refactorit.com

Rename Renames a method, field, type, package or prefix. Updates all references.

Move Class Moves a class or interface into another package.

Encapsulate Field Replaces direct field usage with corresponding accessor methods.

Extract Method Analyzes the selected piece of code and extracts it into a separate method.

Extract Superclass/Interface Extracts selected methods and fields into new superclass or interface.