AntiPatterns and Refactoring

Lehman & Belady: Laws of Software Evolution **(1974)**

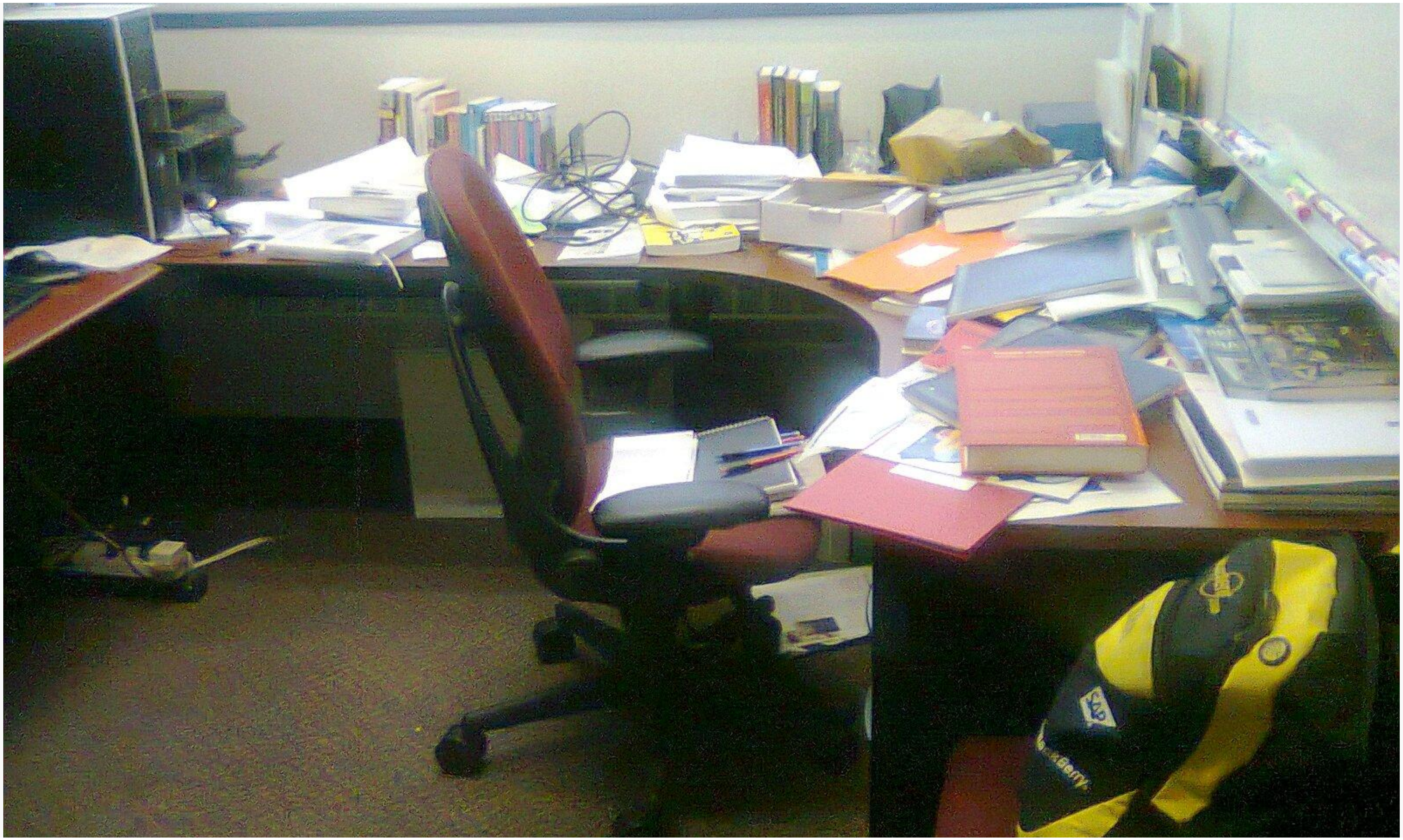
- **Continuing Change** - Systems must be continually adapted else they become progressively less satisfactory.

- **Increasing Complexity** - As a system evolves its complexity increases unless work is done to maintain or reduce it.

It is usually hard to counter, “If it ain’t broke, don’t fix it.”

- Generally improves product quality
- Pay today to ease work tomorrow
- May actually accelerate today’s work

From this…

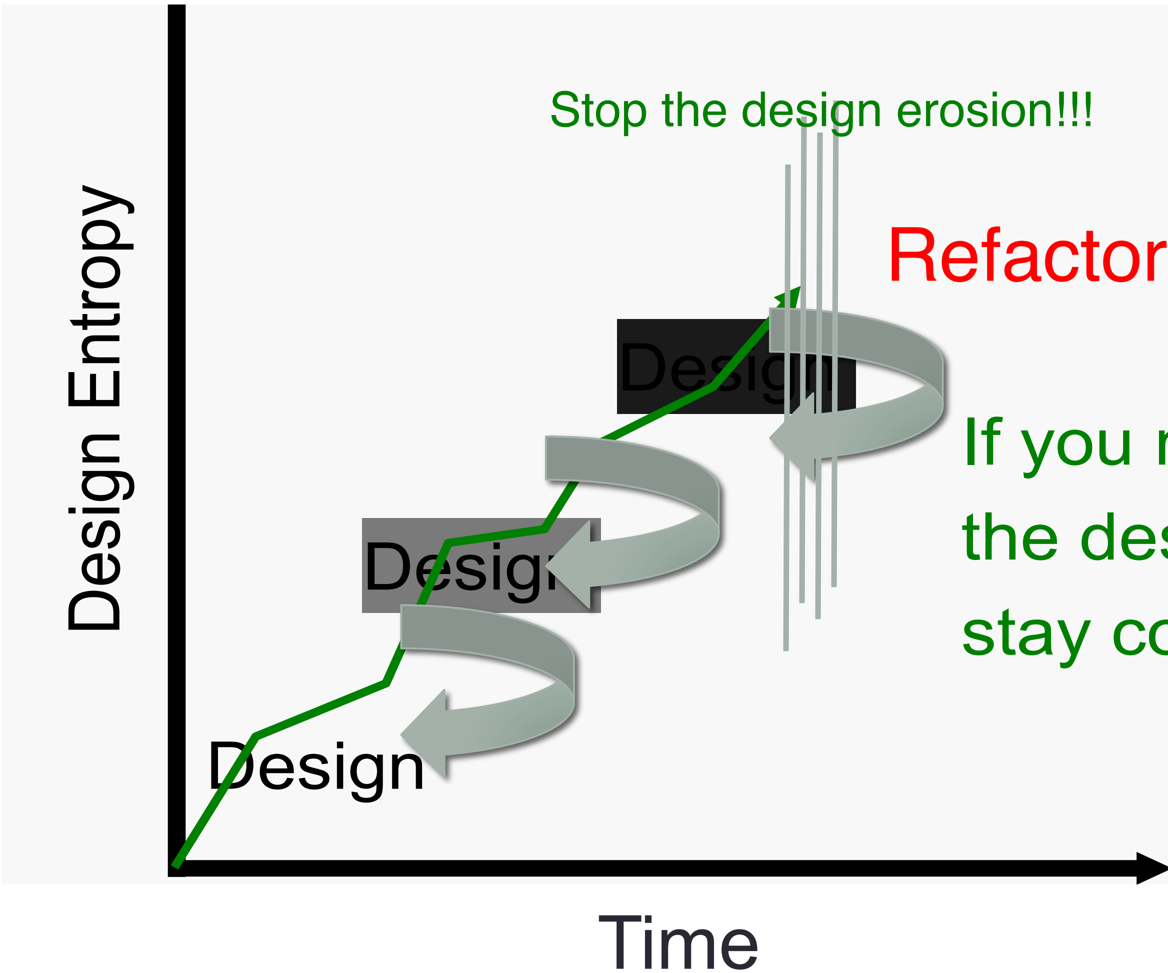


Source: Mike Lutz, RIT

… To this

Source: Mike Lutz, RIT

Design Entropy Vs Time



Refactoring… Can it help?

If you no longer can see the design, how can you stay consistent to it?

Refactoring

- As a software system grows, the overall design often suffers
- In the short term, working in the existing design is cheaper than doing a redesign
- In the long term, the redesign decreases total costs
  - Extensions
  - Maintenance
  - Understanding
- Refactoring is a set of techniques that reduce the short-term pain of redesigning
  - Not adding functionality
  - Changing structure to make it easier to understand and extend

The Scope of Refactoring

- Small steps:
  - Rename a method
  - Move a field from one class to another
  - Merge two similar methods in different classes into one common method in a base class
- Each individual step is small, and easily verified/tested
- The composite effect can be a complete transformation of a system

Principles

- Don't refactor and extend a system at the same time
  - Make a clear separation between the two activities

- Have good tests in place before you begin refactoring
  - Run the tests often
  - Catch defects immediately

- Take small steps
  - Many localized changes result in a larger-scale change
  - Test after each small step

When Should You Refactor?

- You're extending a system, and realize it could be done better by changing the original structure
  - Stop and refactor first
- The code is hard to understand
  - Refactor to gain understanding, and leave the code better than it was

Refactoring and OOD

- The refactoring literature is written from a coding perspective
- Many of the operations still apply at design time
- It helps if you have an appropriate level of detail in the design
  - Too much, and you may as well code
  - Too little, and you can't tell what's happening

Code Smells Within Classes

- **Comments**
  - Are the comments necessary?
  - Do they explain "why" and not "what"?
  - Can you refactor the code so the comments aren't required?
  - Remember, you're writing comments for people, not machines.
- **Long Method**
  - Shorter method is easier to read, easier to understand, and easier to troubleshoot.
  - Refactor long methods into smaller methods if you can
- **Long Parameter List**
  - The more parameters a method has, the more complex it is.
  - Limit the number of parameters you need in a given method, or use an object to combine the parameters.
- **Duplicated code**
  - Stamp out duplication whenever possible.
  - Don't Repeat Yourself!

Code Smells Within Classes

- **Conditional Complexity**
  - large conditional logic blocks, particularly blocks that tend to grow larger or change significantly over time.
  - Consider alternative object-oriented approaches such as decorator, strategy, or state.
- **Combinitorial Explosion**
  - Lots of code that does *almost* the same thing.. but with tiny variations in data or behavior.
  - This can be difficult to refactor-- perhaps using generics or an interpreter?
- **Large Class**
  - Large classes, like long methods, are difficult to read, understand, and troubleshoot.
  - Large class can be restructured or broken into smaller

Code Smells Within Classes

- **Uncommunicative Name**
  - Does the name of the method succinctly describe what that method does? Could you read the method's name to another developer and have them explain to you what it does?
- **Inconsistent Names**
  - set of standard terminology and stick to it throughout your methods.
- **Dead Code**
  - Ruthlessly delete code that isn't being used
- **Speculative Generality**
  - Write code to solve today's problems, and worry about tomorrow's problems when they actually materialize.
  - Everyone loses in the "what if.." school of design.

Code Smells Between Classes

- **Alternative Classes with Different Interfaces**
  - If two classes are similar on the inside, but different on the outside, perhaps they can be modified to share a common interface.

- **Primitive Obsession**
  - If data type is sufficiently complex, write a class to represent it.

- **Data Class**
  - Avoid classes that passively store data.
  - Classes should contain data *and* methods to operate on that data, too.

- **Data Clumps**
  - If you always see the same data hanging around together, maybe it belongs together.
  - Consider rolling the related data up into a larger class.

Code Smells Between Classes

- **Refused Bequest**
  - Inherit from a class but never use any of the inherited functionality
- **Inappropriate Intimacy**
  - Classes that spend too much time together, or classes that interface in inappropriate ways.
  - Classes should know as little as possible about each other
- **Indecent Exposure**
  - Classes that unnecessarily expose their internals.
  - Aggressively refactor classes to minimize their public surface.
  - You should have a compelling reason for every item you make public. If you don't, hide it.
- **Feature Envy**
  - Methods that make extensive use of another class may belong in another class.
  - Move the method to the class it is so envious

Code Smells between Classes

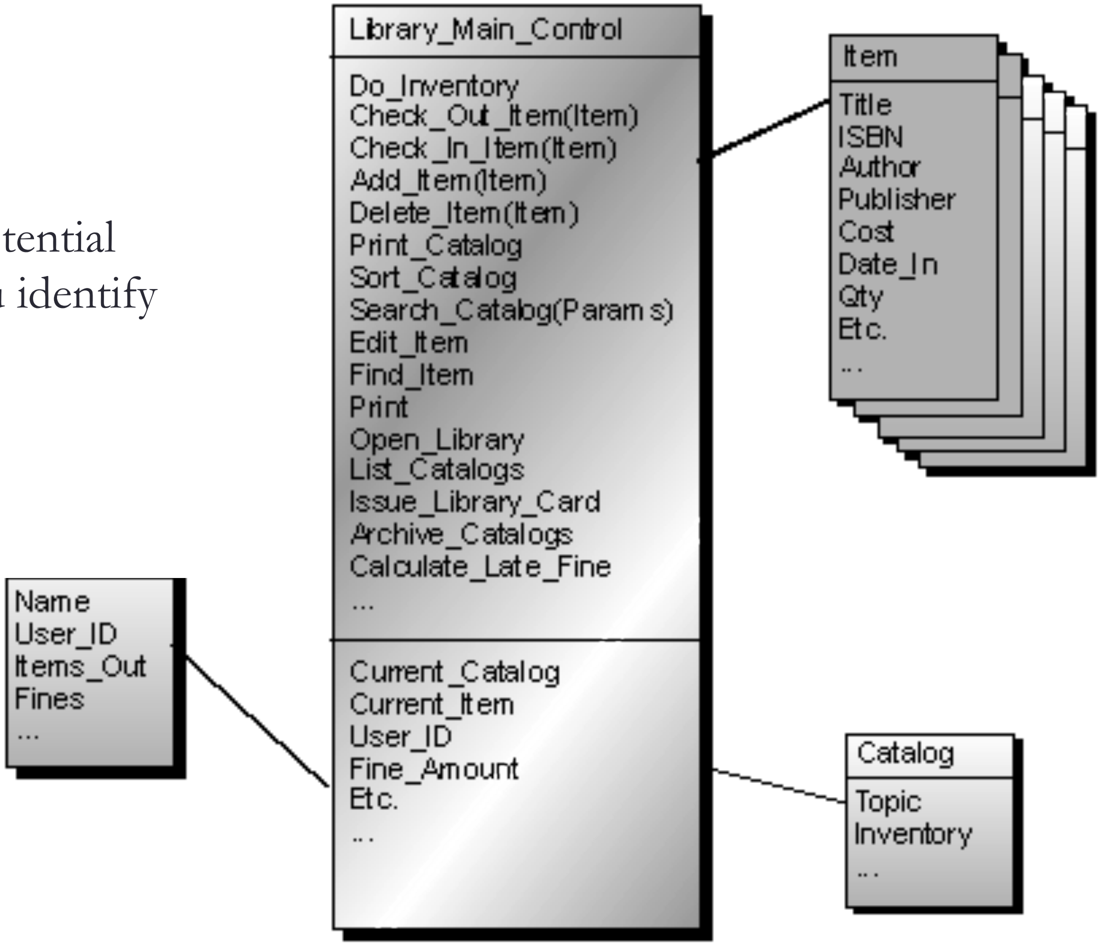
- **Lazy Class**
  - Classes should pull their weight.
  - If a class isn't doing enough to pay for itself, it should be collapsed or combined into another class.
- **Message Chains**
  - Long sequences of method calls or temporary variables to get routine data.
  - Intermediaries are dependencies in disguise.
- **Middle Man**
  - If a class is delegating all its work., then cut out the middleman.
  - Beware classes that are merely wrappers over other classes or existing functionality in the framework.
- **Divergent Change**
  - If changes to a class that touch completely different parts of the class, it may contain too much unrelated functionality.
  - Isolate the parts that changed in another class.

Code Smells between Classes

- **Shotgun Surgery**
  - If a change in one class requires cascading changes in several related classes
- **Parallel Inheritance Hierarchies**
  - Every time you make a subclass of one class, you must also make a subclass of another.
  - Consider folding the hierarchy into a single class.
- **Solution Sprawl**
  - If it takes five classes to do anything useful, you might have solution sprawl.
  - Consider simplifying and consolidating your design.

A simple exercise: Library system - Existing design

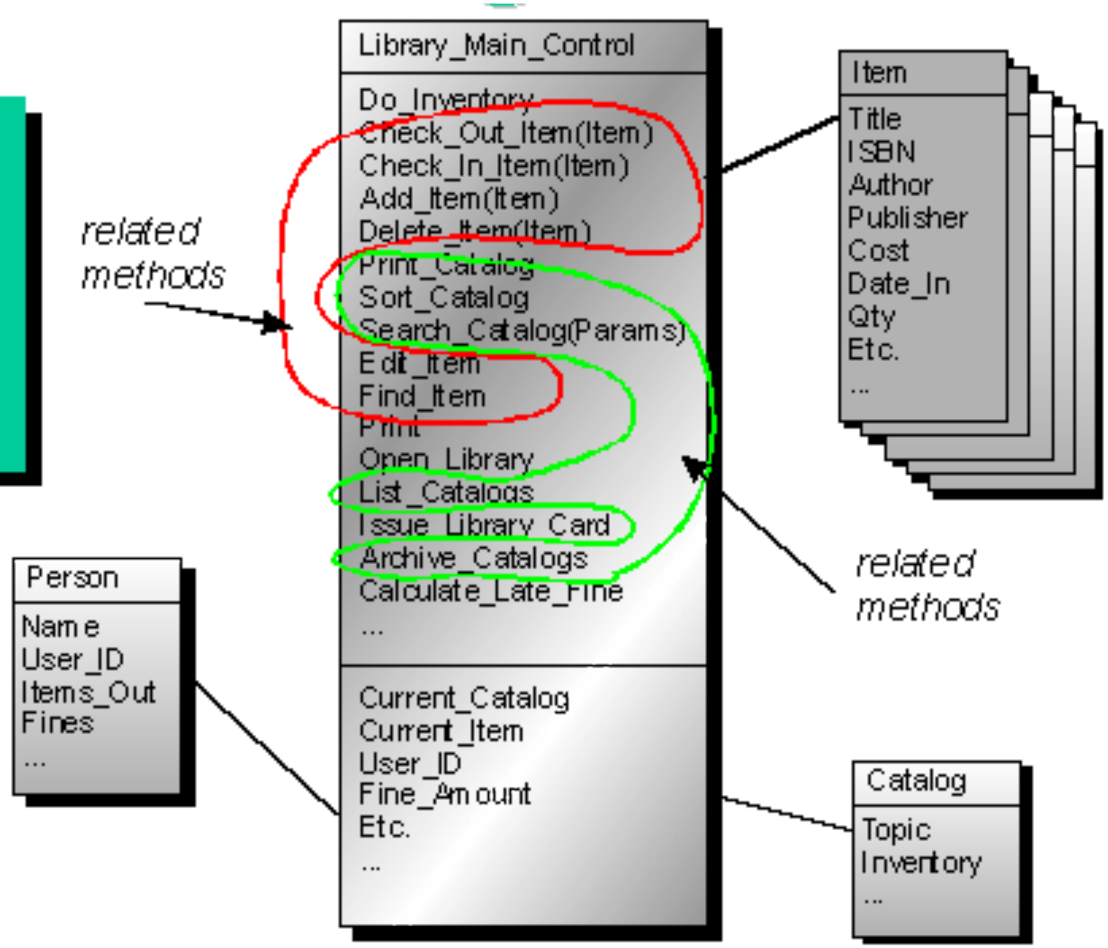
What areas do you see as potential problem areas? Why did you identify each of those areas?



Source: MITRE

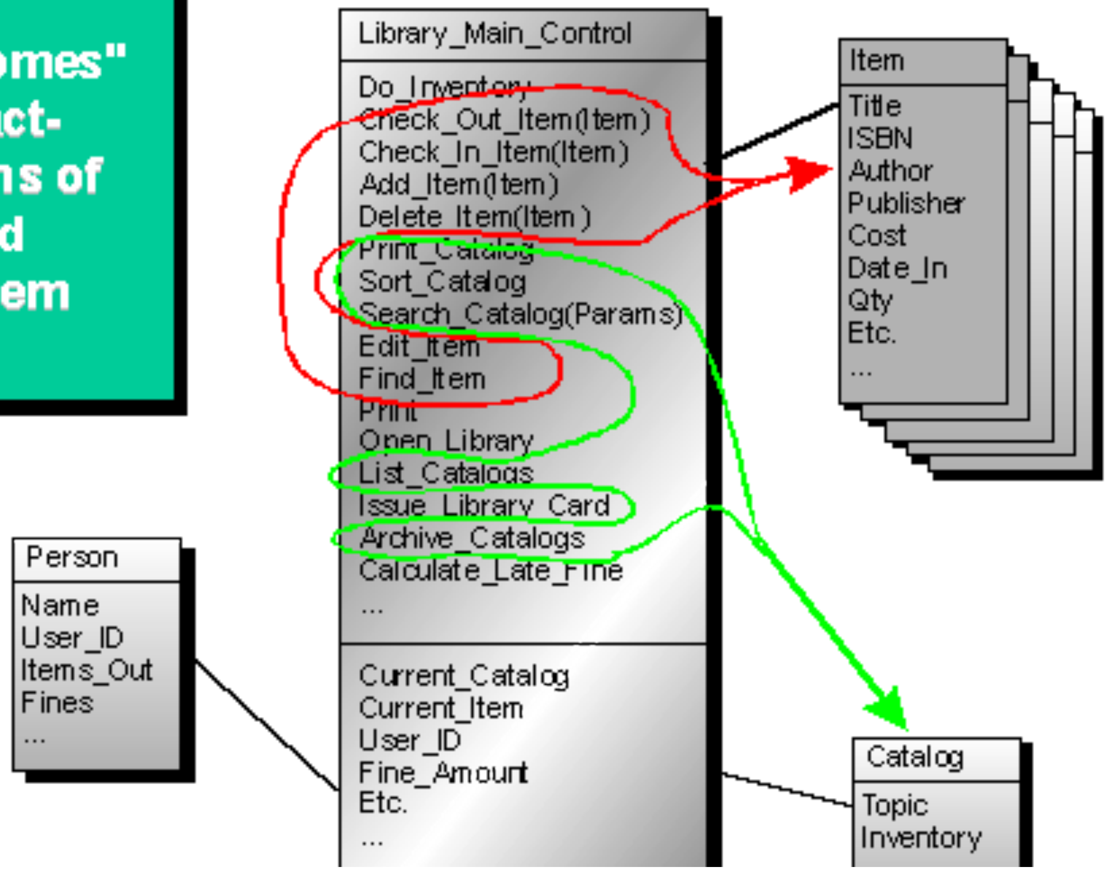
Library system – Changing the design

Step 1:
Identify or categorize related attributes and operations according to contracts.



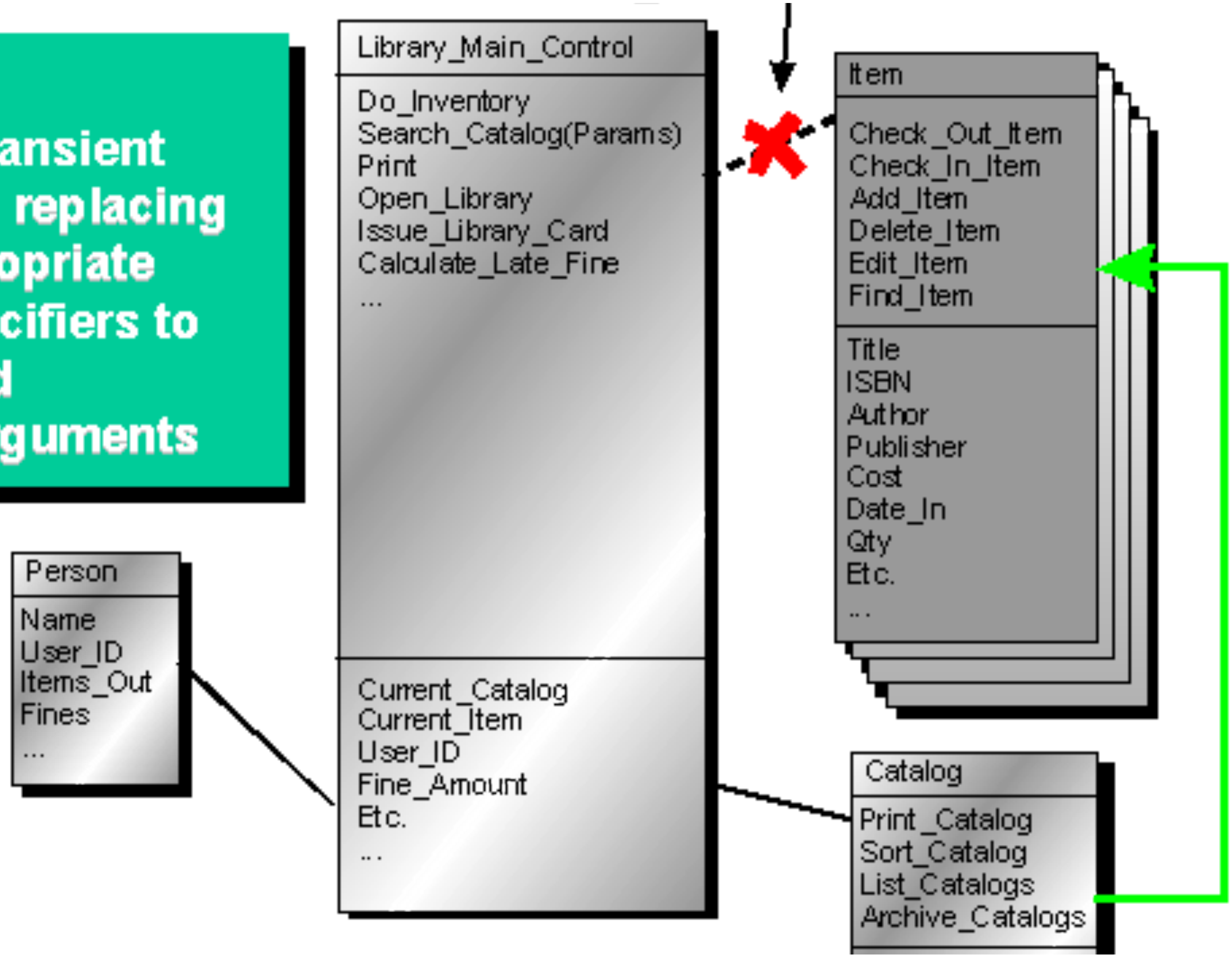
Library system – Changing the design

Step 2:
Find "natural homes" for these contract-based collections of functionality and them migrate them there

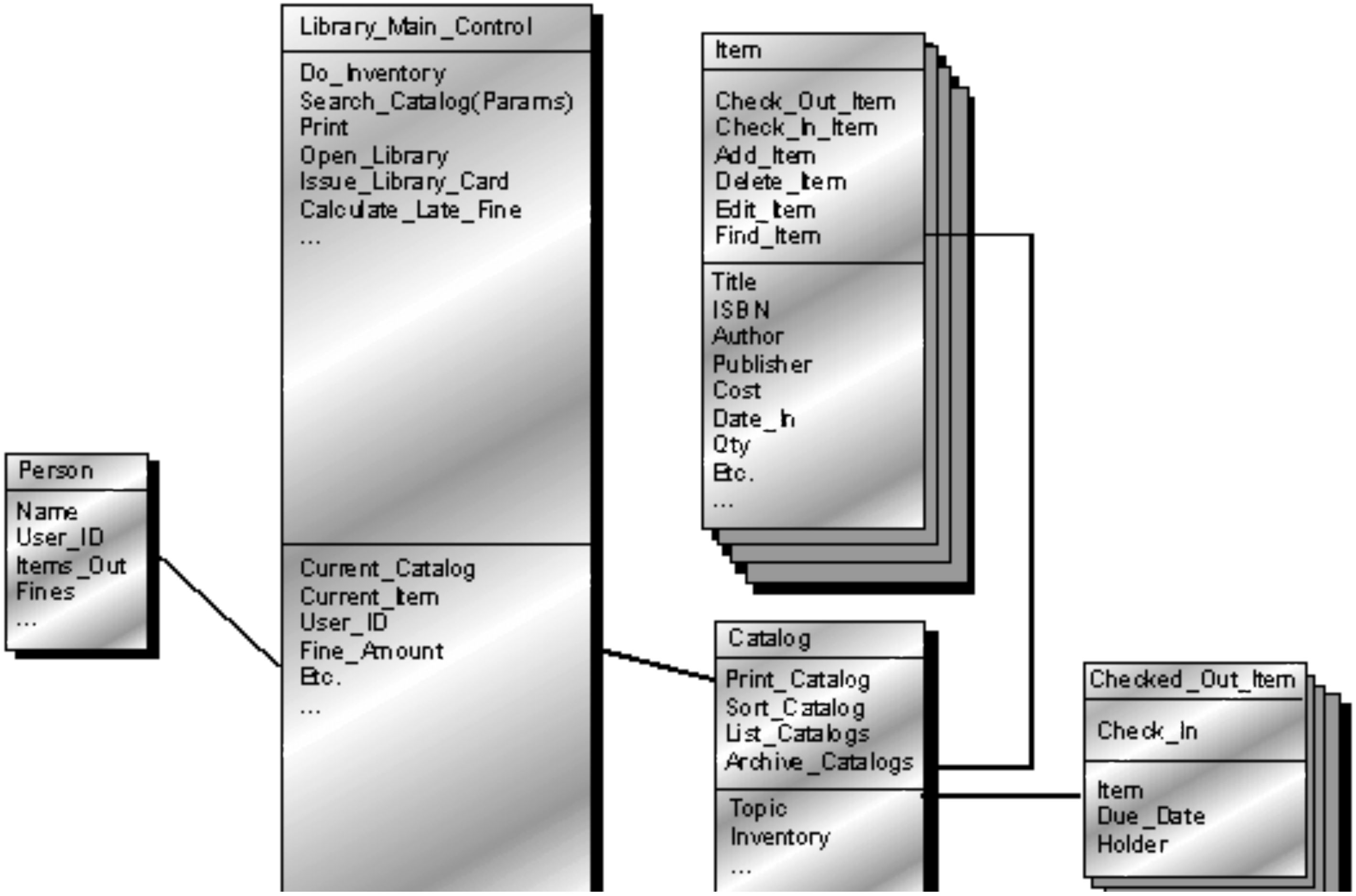


Library system – Changing the design

Final Step:
Remove all transient associations, replacing them as appropriate with type specifiers to attributes and operations arguments



Library system – Changing the design



Another Refactoring Exercise

```
public int getScore()
{
      int result;
      result = (int)(Math.random() * 6) + 1;
      dice[0].setFaceValue(result);

      result = (int)(Math.random() * 6) + 1;
      dice[1].setFaceValue(result);

      int score = dice[0].getFaceValue() +
                       dice[1].getFaceValue();
      return score;
}
```

/* Assume that dice is an array of Die objects and has access to ‘faceValue’ property */

Writing test cases…

- Prepare the test cases before any/every change made…

For example, a test framework such as JUnit can check the values:

```
assertTrue(diceValue >= 2 && diceValue <=12);
```

Refactoring No. 1 - Self Encapsulate field

```
dice[0].setFaceValue(result)
Gets replaced by

getDice(0).setFaceValue(result)

=====================================
public int getScore()
{
       int result;
       result = (int)(Math.random() * 6) + 1;
       getDice(0).setFaceValue(result);

       result = (int)(Math.random() * 6) + 1;
       getDice(1).setFaceValue(result);

       int score = getDice(0).getFaceValue() + getDice(1).getFaceValue();
       return score;
}
```

/* This refactoring tells us not to directly access an object's fields within its methods, but to use accessor methods */

Refactoring No. 2 - Extract Method

```
// roll the die
result = (int)(Math.random() * 6) + 1;
can become
result = rollDie();
====================================
   public int getScore()
   {
          int result;
          result = rollDie();
          getDice(0).setFaceValue(result);
          result = rollDie();
          getDice(1).setFaceValue(result);
          int score = getDice(0).getFaceValue() + getDice(1).getFaceValue();
          return score;
   }

   public int rollDie() {
          return (int)(Math.random() * 6) + 1;
   }
```

/* This refactoring tells us to extract lines of code from long method and make it a separate method */

Refactoring No. 3 – Rename method/class/variable/etc.

```
Change getScore to ThrowDice()

It might be confusing if player scores are to be computed
==================================
public int ThrowDice()
{
        int result;
        result = rollDie();
        getDice(0).setFaceValue(result);
        result = rollDie();
        getDice(1).setFaceValue(result);
        int score = getDice(0).getFaceValue() + getDice(1).getFaceValue();
        return score;
}

public int rollDie() {
        return (int)(Math.random() * 6) + 1;
}
```

/* Changing the names in code (of classes, methods, variables etc.) to be more meaningful can make a positive contribution to code readability */

Refactoring No. 4 – Replace Temp with Query

```
public int ThrowDice()
{
       int result;
       result = rollDie();
       getDice(0).setFaceValue(result);
       result = rollDie();
       getDice(1).setFaceValue(result);
       return getDiceValue();
}

public int rollDie() {
       return (int)(Math.random() * 6) + 1;
}

// replace temp variable score with query
public int getDiceValue() {
int score = getDice(0).getFaceValue() + getDice(1).getFaceValue();
return getDice(0).getFaceValue() + getDice(1).getFaceValue();
       return score;
}
```

/* This refactoring encourages us to use methods directly in code rather then storing their results in temporary variables.*/

Refactoring No. 5 – Move Method

```
public void roll() {
  setFaceValue((int)(Math.random() * 6) + 1);
}
============================================
   public int ThrowDice(){
          int result;
          result = rollDie();
          getDice(0).setFaceValue(result);
          getDice(0).roll();
          result = rollDie();
          getDice(1).setFaceValue(result);
          getDice(1).roll()
          return getDiceValue();
   }

   public int rollDie() {
          return (int)(Math.random() * 6) + 1;
   }
  public void roll() {
          setFaceValue((int)(Math.random() * 6) + 1);
  }
   public int getDiceValue() {
          return getDice(0).getFaceValue() + getDice(1).getFaceValue();
   }
```

/* This refactoring involves moving a method from one class to another, so can potentially be quite difficult because of the possible side effects */

Recap…

- Designs can deteriorate over a period of time
- Refactoring can help in managing the deterioration of design
  - One small step at a time
  - Don’t refactor and add functionality at the same time

ANTI PATTERNS

Material adapted from "AntiPatterns: Refactoring Software, Architectures, and Projects in Crisis" by William J Brown et. al.

AntiPatterns

- A pattern of practice that is commonly found in use
- A pattern which when practiced usually results in *negative* consequences
- Patterns defined in several categories of software development
  - Design
  - Architecture
  - Project Management

Purpose for AntiPatterns

- Identify problems
- Develop and implement strategies to fix
    - Work incrementally
    - Many alternatives to consider
    - Beware of the cure being worse than the disease

Software Design AntiPatterns

- AntiPatterns
  - The Blob
  - Lava Flow
  - Functional Decomposition
  - Poltergeists
  - Golden Hammer
  - Spaghetti Code
  - Cut-and-Paste Programming
- Mini-AntiPatterns
  - Continuous Obsolescence
  - Ambiguous Viewpoint
  - Boat Anchor
  - Dead End
  - Input Kludge
  - Walking through a Minefield
  - Mushroom Management

The Blob

- AKA
  - Winnebago, The God Class, Kitchen Sink Class
- Causes
  - Sloth, haste
- Unbalanced Forces:
  - Management of Functionality, Performance, Complexity
- Anecdotal Evidence:
  - "This is the class that is really the *heart* of our architecture."

The Blob (2)

- Like the blob in the movie can consume entire object-oriented architectures
- Symptoms
  - Single controller class, multiple simple data classes
  - No object-oriented design, i.e. all in main
  - Start with a legacy design
- Problems
  - Too complex to test or reuse
  - Expensive to load into system

Causes

- Lack of OO architecture
- Lack of any architecture
- Lack of architecture enforcement
- Limited refactoring intervention
- Iterative development
  - Proof-of-concept to prototype to production
  - Allocation of responsibilities not repartitioned

Solution

- Identify or categorize related attributes and operations
- Migrate functionality to data classes
- Remove far couplings and migrate to data classes

Lava Flow

- AKA
  - Dead Code
- Causes
  - Avarice, Greed, Sloth
- Unbalanced Forces
  - Management of Functionality, Performance, Complexity

Symptoms and Consequences

- Unjustifiable variables and code fragments
- Undocumented complex, important-looking functions, classes
- Large commented-out code with no explanations
- Lot’s of “to be replaced” code
- Obsolete interfaces in header files
- Proliferates as code is reused

Causes

- Research code moved into production
- Uncontrolled distribution of unfinished code
- No configuration management in place
- Repetitive development cycle

Solution

- Don't get to that point
- Have stable, well-defined interfaces
- Slowly remove dead code; gain a full understanding of any bugs introduced
- Strong architecture moving forward

Functional Decompostion

- AKA
  - No OO
- Root Causes
  - Avarice, Greed, Sloth
- Unbalanced Forces
  - Management of Complexity, Change
- Anecdotal Evidence
  - "This is our 'main' routine, here in the class called Listener."

Symptoms and Consequences

- Non-OO programmers make each subroutine a class
- Classes with functional names
  - Calculate_Interest
  - Display_Table
- Classes with single method
- No leveraging of OO principles
- No hope of reuse

Causes

- Lack of OO understanding
- Lack of architecture enforcement
- Specified disaster

Solution

- Perform analysis
- Develop design model that incorporates as much of the system as possible
- For classes outside model:
    - Single method: find home in existing class
    - Combine classes

Poltergeists

- AKA
  - Gypsy, Proliferation of Classes
- Root Causes
  - Sloth, Ignorance
- Unbalanced Forces
  - Management of Functionality, Complexity
- Anecdotal Evidence
  - "I'm not exactly sure what this class does, but it sure is important."

Symptoms and Consequences

- Transient associations that go "bump-in-the-night"
- Stateless classes
- Short-lived classes that begin operations
- Classes with control-like names or suffixed with *manager* or *controller*. Only invoke methods in other classes.

Causes

- Lack of OO experience
- Maybe OO is incorrect tool for the job. “There is no right way to do the wrong thing.”

Solution

- Remove Poltergeist altogether
- Move controlling actions to related classes

Cut-and-Paste Programming

- AKA
  - Clipboard Coding
- Root Causes
  - Sloth
- Unbalanced Forces
  - Management of Resources, Technology Transfer
- Anecdotal Evidence
  - "Hey, I thought you fixed that bug already, so why is it doing this again?" "Man, you guys work fast. Over 400,000 lines of code in three weeks is outstanding progress!"

Symptoms and Consequences

- Same software bug reoccurs
- Code can be reused with a minimum of effort
- Causes excessive maintenance costs
- Multiple unique bug fixes develop
- Inflates LOC without reducing maintenance costs

Causes

- Requires effort to create reusable code; must reward for long-term investment
- Context or intent of module not preserved
- Development speed overshadows all other factors
- "Not-invented-here" reduces reuse
- People unfamiliar with new technology or tools just modify a working example

Solution

- Code mining to find duplicate sections of code
- Refactoring to develop standard version
- Configuration management to assist in prevention of future occurrence

Golden Hammer

- AKA
  - Old Yeller
- Root Causes
  - Ignorance, Pride, Narrow-Mindedness
- Unbalanced Forces
  - Management of Technology Transfer
- Anecdotal Evidence
  - "Our database is our architecture" "Maybe we shouldn't have used Excel macros for this job after all."

Symptoms and Consequences

- Identical tools for conceptually diverse problems. "When your only tool is a hammer everything looks like a nail."
- Solutions have inferior performance, scalability and other 'ilities' compared to other solutions in the industry.
- Architecture is described by the tool set.
- Requirements tailored to what tool set does well.

Causes

- Development team is highly proficient with one toolset.
- Several successes with tool set.
- Large investment in tool set.
- Development team is out of touch with industry.

Solution

- Organization must commit to exploration of new technologies
- Commitment to professional development of staff
- Defined software boundaries to ease replacement of subsystems
- Staff hired with different backgrounds and from different areas
- Use open systems and architectures