Quality Assurance and Software Evolution

Course outline

1. Software Evolution and Reengineering
2. Model Capture and Design Extraction
3. Object-Oriented Harmony ... and Its Disharmonies
4. Detecting Disharmonies
5. Refactoring and Restructuring

Textbooks

1. Introduction

- Goals
- Terminology
- Why Reengineering ?
  - Object-Oriented Legacy
  - Lehman's Laws
- Typical Problems
  - common symptoms
  - architectural problems & refactorings opportunities
- Reverse and Reengineering
  - Techniques
  - Patterns

Goals of this course

We will try to convince you:

- There are **object-oriented** legacy systems too!
- Reverse engineering and reengineering are essential activities in the lifecycle of any successful software system.
  - And especially OO ones!
- There is a large set of lightweight tools and techniques to help you with the quality assessment and the evolution of your software.
- Despite these tools and techniques, people must do the job and they represent the most valuable resource.

What is a Legacy System ?

legacy

A sum of money, or a specified article, given to another by will; anything handed down by an ancestor or predecessor. — Oxford English Dictionary

A **legacy system** is a piece of software that:
- you have inherited, and
- is valuable to you.

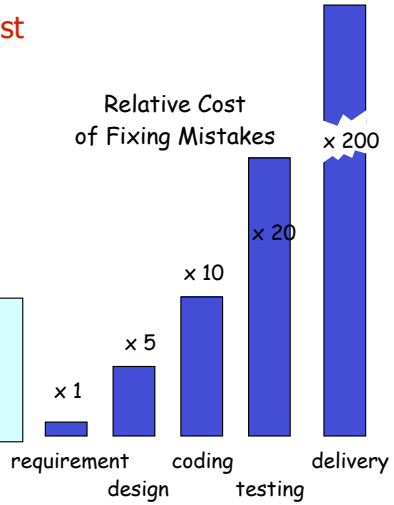
Typical **problems** with legacy systems are:
- original developers no longer available
- outdated development methods used
- extensive patches and modifications
- missing or outdated documentation

⇒ so, further evolution and development may be prohibitively expensive

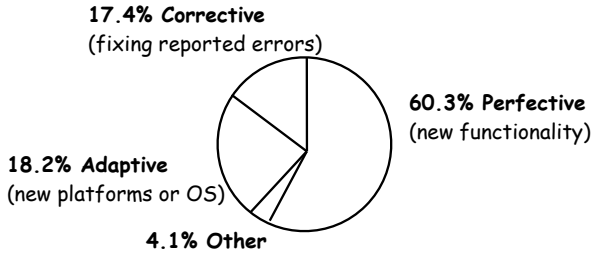
Software Maintenance - Cost

Relative Maintenance Effort
Between 50% and 75% of global effort is spent on maintenance !

Solution ?
- Better requirements engineering
- Better software methods & tools (database schemas, CASE-tools, objects, components, …)



Requirements Engineering ?



The bulk of the maintenance cost is due to new functionality
⇒ even with better requirements, it is hard to predict new functions

Lehman's Laws

A classic study by Lehman and Belady [Lehm85a] identified several "laws" of system change.

Continuous Change

- A program that is used in a real-world environment **must change**, or become progressively less useful in that environment.

Increasing complexity

- As a program evolves, it becomes **more complex**, and extra resources are needed to preserve and simplify its structure.

These laws are still applicable…

What about Objects ?

Object-oriented legacy systems

- = successful OO systems whose architecture and design no longer responds to changing requirements

Compared to traditional legacy systems

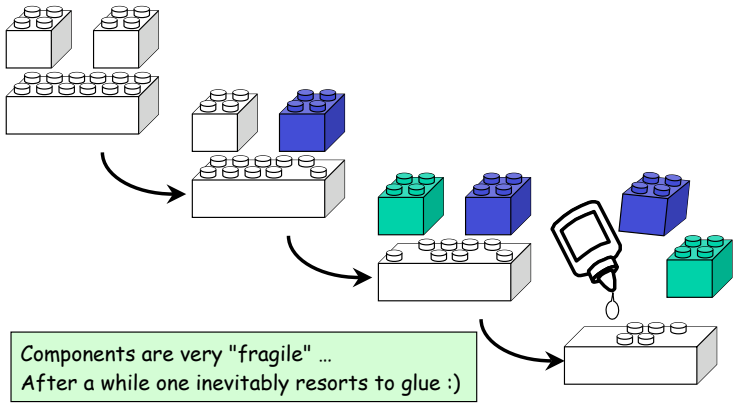
- The symptoms and the source of the problems are the same
  - ravioli code instead of spaghetti code ;)
- The technical details and solutions may differ

OO techniques promise better

- flexibility,
- reusability,
- maintainability
- …

⇒ they do not come for free

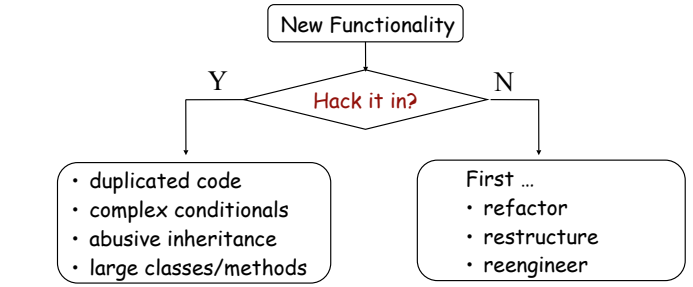
What about Components ?



Components are very "fragile" …
After a while one inevitably resorts to glue :)

How to deal with Legacy ?

New or changing requirements will gradually degrade original design
… unless extra development effort is spent to adapt the structure



Take a loan on your software
⇒ pay back via reengineering

Investment for the future
⇒ paid back during maintenance

Common Symptoms

Lack of Knowledge

- obsolete or no documentation
- departure of the original developers or users
- disappearance of inside knowledge about the system
- limited understanding of entire system
- missing tests

Process symptoms

- too long to turn things over to production
  - simple changes take too long
- need for constant bug fixes
- maintenance dependencies
- difficulties separating products

Code symptoms

- big build times
- duplicated code
- code smells

Common Problems

Architectural Problems

- insufficient documentation
  - non-existent or out-of-date
- improper layering
  - too few are too many layers
- lack of modularity
  - strong coupling
- duplicated functionality
  - similar functionality by separate teams

Refactoring opportunities

- misuse of inheritance
  - code reuse vs polymorphism
- missing inheritance
  - duplication, case-statements
- misplaced operations
  - operations outside classes
- violation of encapsulation
  - type-casting; C++ "friends"
- class abuse
  - classes as namespaces
- duplicated code
  - copy, paste & edit code

Some Terminology

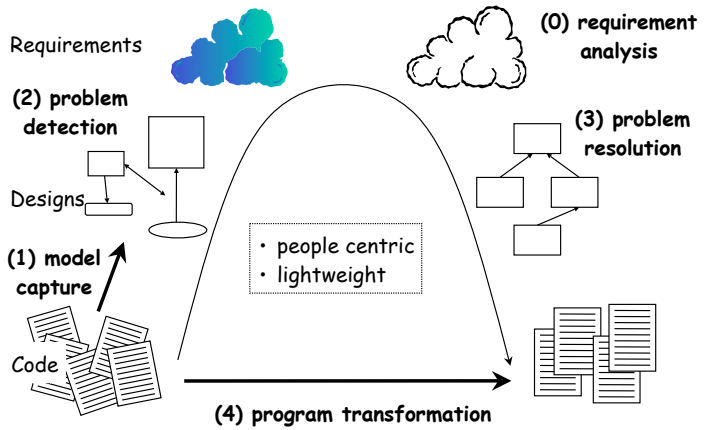
"Forward Engineering is the traditional process of moving from high-level abstractions and logical, implementation-independent designs to the physical implementation of a system."

"Reverse Engineering is the process of analyzing a subject system to identify the system's components and their interrelationships and create representations of the system in another form or at a higher level of abstraction."

"Reengineering ... is the examination and alteration of a subject system to reconstitute it in a new form and the subsequent implementation of the new form."

— Chikofsky and Cross [in Arnold, 1993]

The Reengineering Life-Cycle



Goals of Reverse Engineering

- Cope with complexity
  - need techniques to understand large, complex systems
- Generate alternative views
  - automatically generate different ways to view systems
- Recover lost information
  - extract what changes have been made and why
- Synthesize higher abstractions
  - identify latent abstractions in software
- Facilitate reuse
  - detect candidate reusable artifacts and components

Chikofsky and Cross [in Arnold, 1993]

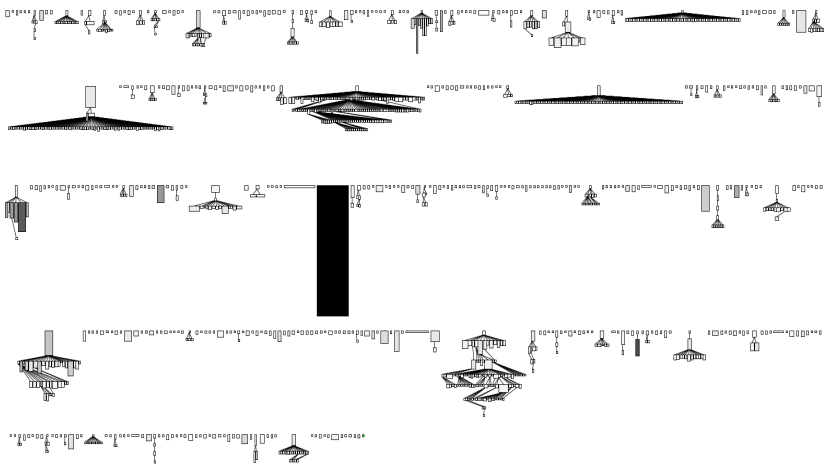
Reverse Engineering Techniques

- Redocumentation
  - pretty printers
  - diagram generators
    - e.g. Together
  - cross-reference listing generators
    - e.g. IDEA, SNiFF+, Source Navigator
- Design recovery
  - software metrics
  - browsers, visualization tools
  - static analyzers
  - dynamic (trace) analyzers

Goals of Reengineering

- Unbundling
  - split a monolithic system into parts that can be separately marketed
- Performance
  - "**first do it, then do it right, then do it fast**"
    - experience shows this is the right sequence!
- Design refinement
  - to improve maintainability, portability, etc.
- Port to other Platform
  - the architecture must distinguish the platform dependent modules
- Exploitation of New Technology
  - i.e., new language features, standards, libraries, etc.

A Picture is Worth a Thousand Words...



System Complexity View of ArgoUML

FAMOOS Project

FAMOOS Case studies

Domain	LOC	Reengineering Goal
pipeline planning	55,000	extract design
user interface	60,000	increase flexibility
embedded switching	180,000	improve modularity
mail sorting	350,000	portability & scalability
network management	2,000,000	unbundle application
space mission	2,500,000	identify components

Different reengineering goals … but common themes and problems !

Reengineering Techniques

- Restructuring
  - automatic conversion from unstructured to structured code
  - source code translation

  [Chikofsky and Cross93]
- Refactoring
  - renaming/moving methods/classes etc.

  [Fowler99]
- Data reengineering
  - integrating and centralizing multiple databases
  - unifying multiple, inconsistent representations
  - upgrading data models

  [Sommerville, ch 32]

Reverse engineering Patterns

Reverse engineering patterns
- encode expertise and trade-offs in
  - extracting design from source code,
  - running systems and
  - people.

- Even if design documents exist, they are typically out of sync with reality.

Example: **Refactor to Understand**

Reengineering Patterns

Reengineering patterns
- encode expertise and trade-offs in transforming legacy code to
  - resolve problems that have emerged.

- These problems are typically not apparent in original design but are due to architectural drift as requirements evolve

Example: **Move Behaviour Close to Data**

Summary

- Software "maintenance" is really continuous development
- Object-oriented software also suffers from legacy symptoms
- Reengineering goals differ; symptoms don't
- Common, lightweight techniques can be applied to keep software healthy