Introduction to Object-Oriented Reengineering

Course outline

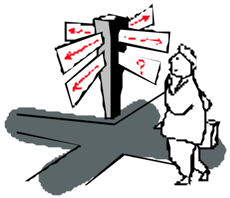
1. Introduction
2. Reverse Engineering
3. Design and Architectural Extraction
4. Visualization for Program Understanding
5. Principles of Good Object-Oriented Design (part 1)
6. Principle of Good Object-Oriented Design (part 2)
7. Problem Detection
8. Testing and Migration Strategies
9. Refactoring and Restructuring

OOR

Object-Oriented Reengineering

- Text:
  - “Object-Oriented Reengineering Patterns,” Serge Demeyer, Stéphane Ducasse and Oscar Nierstrasz, Morgan Kaufmann and DPunkt, 2002, ISBN 1-55860-639-4.
  - "FAMOOS Object-Oriented Reengineering Handbook", H. Baer, M. Bauer, O. Ciupke, S. Demeyer, S. Ducasse, M. Lanza, R.Marinescu, R. Nebbe, O. Nierstrasz, Michael Przybilski, T. Richner, M. Rieger, C. Riva, A.-M. Sassen, B. Schulz, P. Steyaert, S. Tichelaar, J. Weisbrod, 1999

1. Introduction



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

Goals of this course

We will try to convince you:

- Yes, Virginia, 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 reengineering.
- Despite these tools and techniques, *people must do 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.

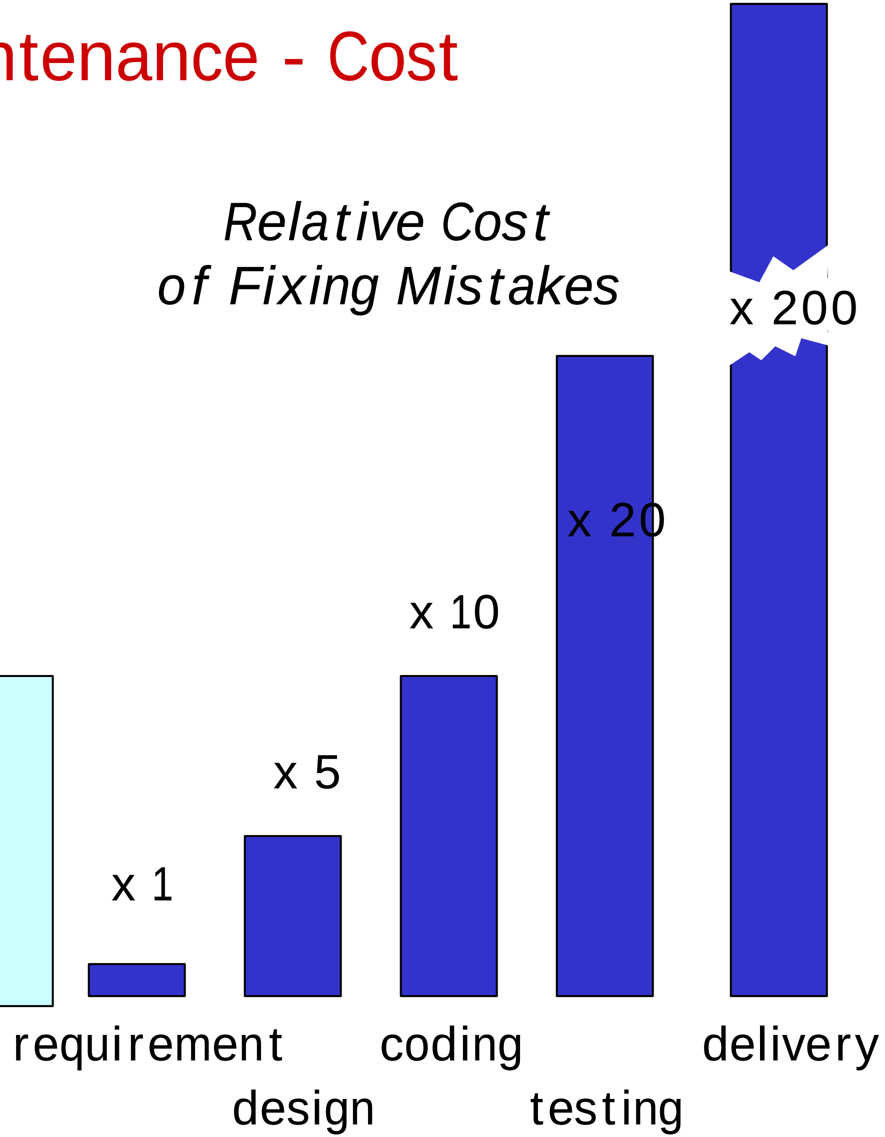
Typical **problems** with legacy systems are:
- original developers no longer available
- outdated development methods used
- extensive patches and modifications
- missing or outdated documentation

⇒ *so, further evolution and development may be prohibitively expensive*

Software Maintenance - Cost

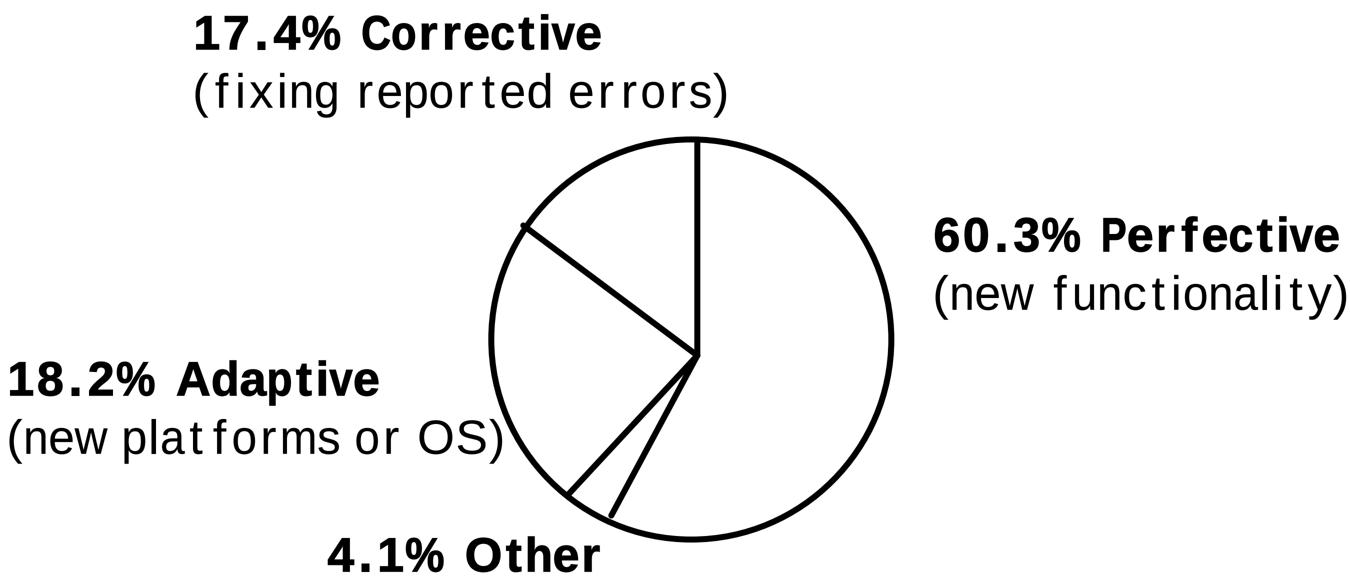
Relative Maintenance Effort
Between 50% and 75% of global effort is spent on maintenance !

Relative Cost of Fixing Mistakes



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

Modern Methods & Tools ?

[Glas98a] quoting empirical study from Sasa Dekleva (1992)

- Modern methods(*) lead to more reliable software
- Modern methods lead to less frequent software repair
- and ...
- Modern methods lead to more total maintenance time

Contradiction ? *No!*
- modern methods make it easier to change
  ... this capacity is used to enhance functionality!

(*) process-oriented structured methods, information engineering, data-oriented methods, prototyping, CASE-tools – not OO !

Lehman's Laws

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

Continuing 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

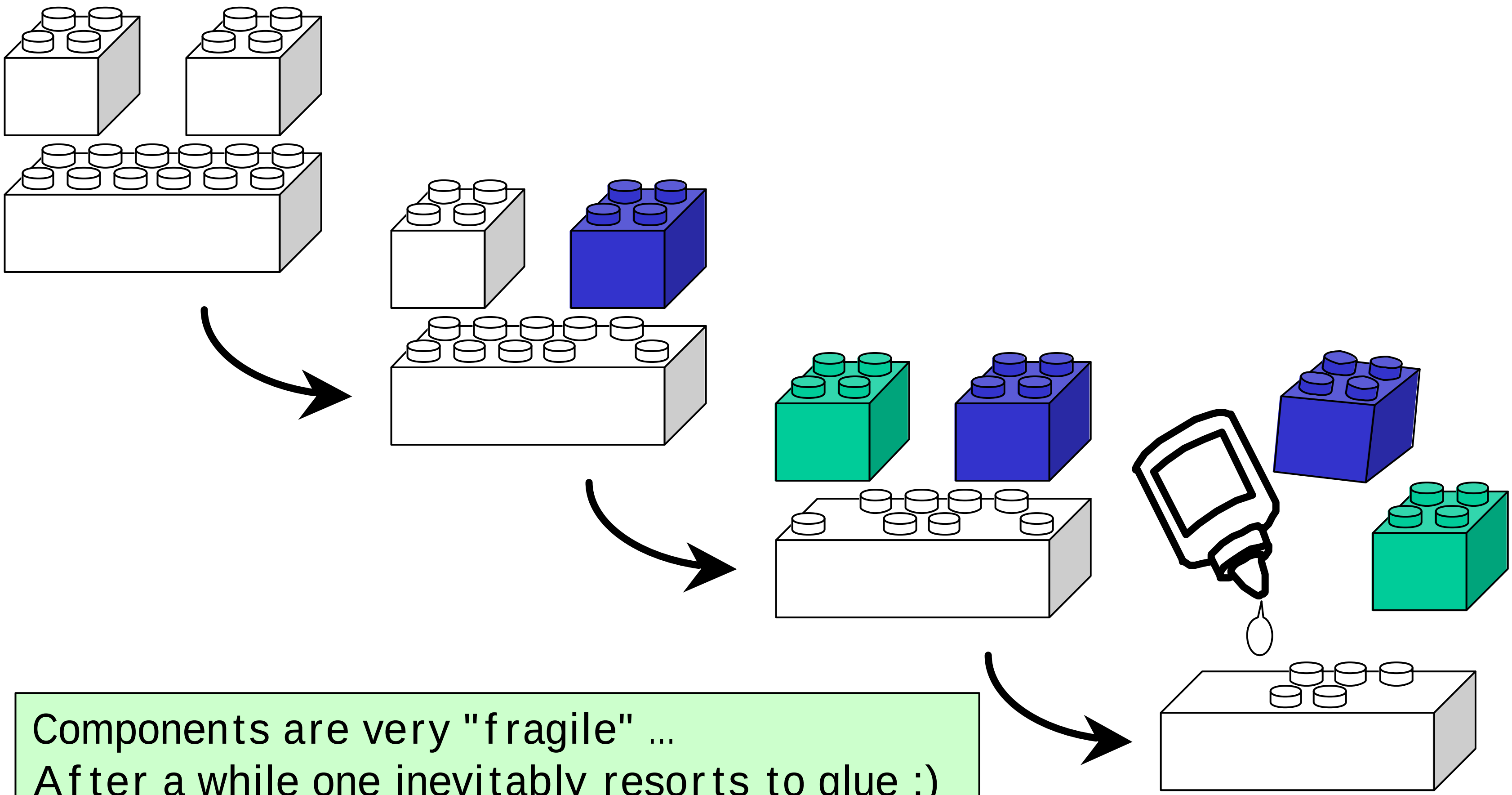
- The symptoms and the source of the problems are the same
  - ravioli code instead of spaghetti code ;)
- The technical details and solutions may differ

OO techniques promise better

- flexibility,
- reusability,
- maintainability
- ...

$\Rightarrow$ they do not come for free

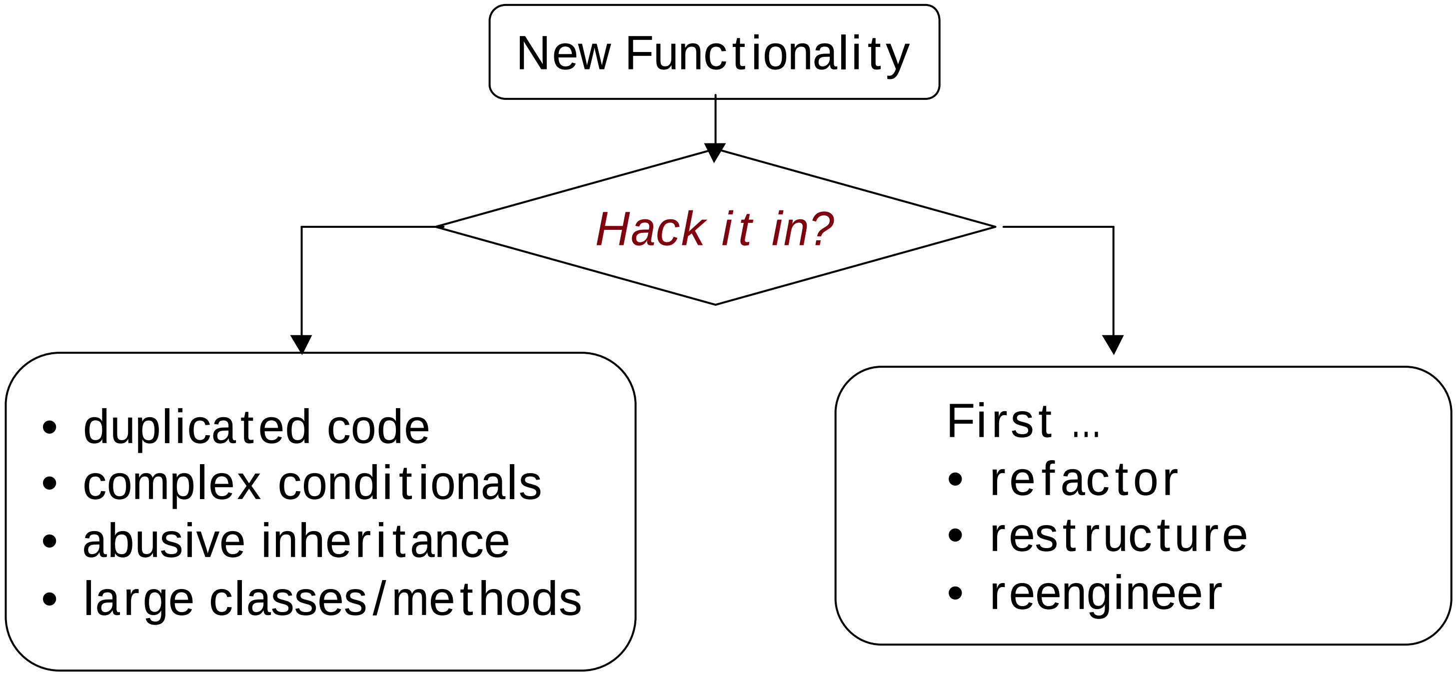
What about Components ?



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

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 !

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 code*
  - copy, paste & edit code
- 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

Some Terminology

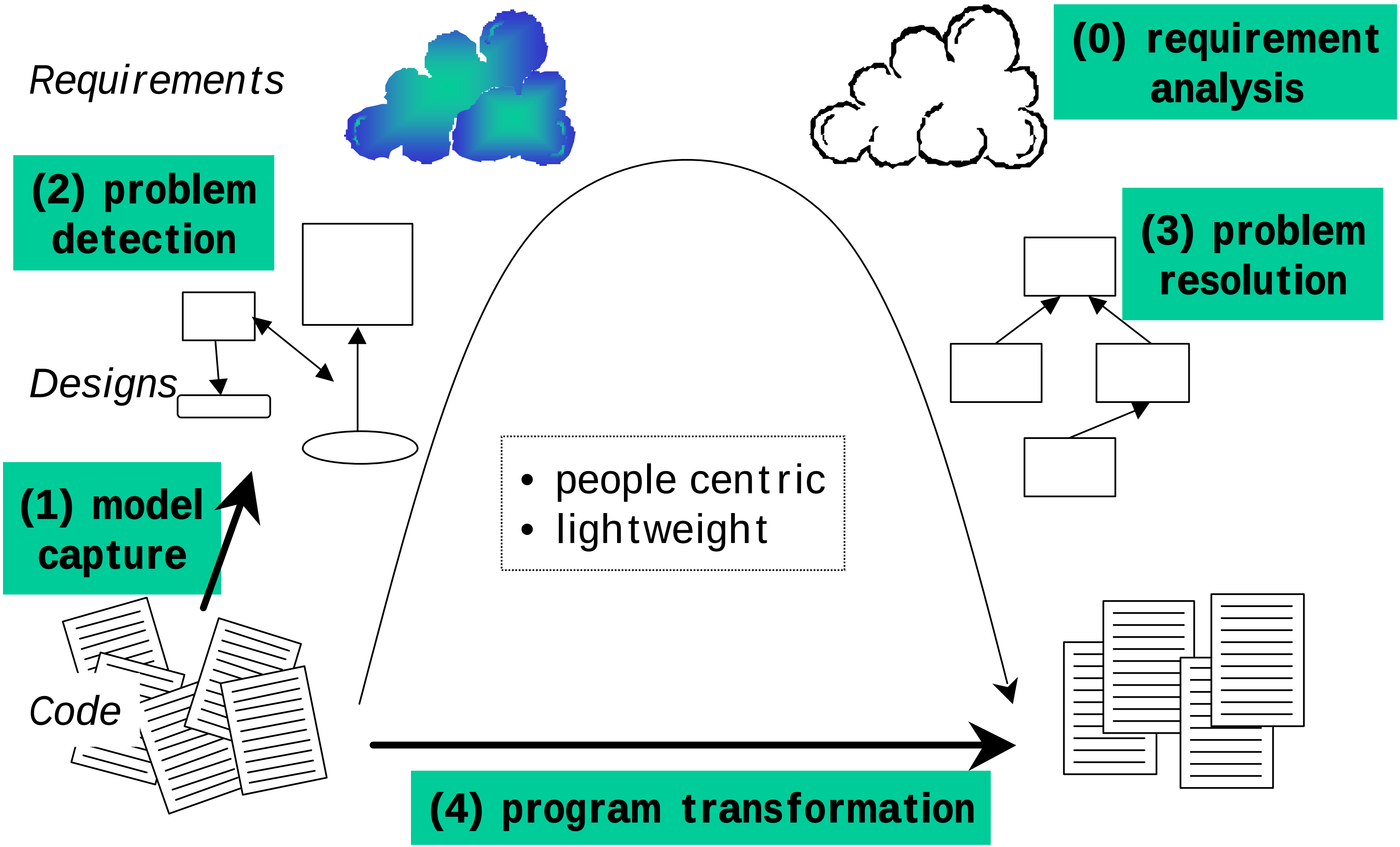
"*Forward Engineering* is the traditional process of moving from high-level abstractions and logical, implementation-independent designs to the physical implementation of a system."

"*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
- Detect *side effects*
  - help understand ramifications of changes
- 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.

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: **Interview During Demo**

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