# Software Re-Engineering

COSC 6431

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# The Legacy Dilemma

## Legacy Systems

- Older software systems that remain vital to an organization
- Software systems that are developed specially for an organization have a long lifetime
- Many software systems that are still in use were developed many years ago using technologies that are now obsolete

## Legacy System Replacement

- There is a business risk in scrapping a legacy system and replacing it with a modern system:
  - Legacy systems rarely have a complete specification.
  - Business processes rely on the legacy system.
  - The system may embed business rules that are not formally documented elsewhere.
  - New software development is risky and may not be successful.

## Laws of Software Evolution

Also known as Lehman's Laws

**Law of Increasing Complexity**

As a program is evolved its complexity increases unless work is done to maintain or reduce it

**Law of Continuing Growth**

Functional content of a program must be continually increased to maintain user satisfaction over its lifetime

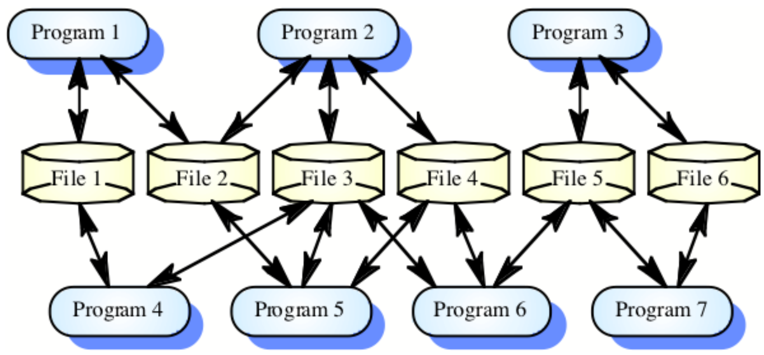
## Legacy System Change is Expensive

- Different parts of the system are implemented by different teams.
- The system may use an obsolete programming language.
- The system documentation is often out-of-date.
- The system structure may be corrupted by many years of maintenance.
- Techniques to save space or increase speed at the expense of understandability may have been used

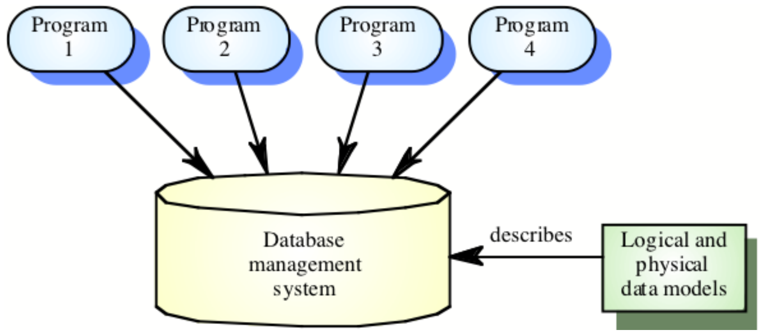
## The Legacy Dilemma

- It is expensive and risky to replace the legacy system.
- It is expensive to maintain the legacy system.
- Businesses may choose to extend the system lifetime using techniques such as reverse engineering.

## Example of a Legacy Application System




## After Re-engineering: Database-Centred System



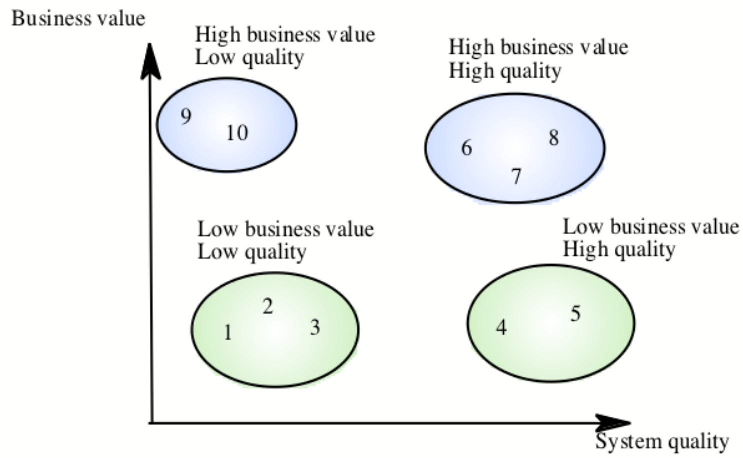

## Legacy System Design

- Most legacy systems were designed before object-oriented development was used.
- Rather than being organized as a set of interacting objects, these systems have been designed using a function-oriented design strategy.

## Legacy System Assessment

- Organizations that rely on legacy systems must choose a strategy for evolving these systems:
  - Replace the old system with a new one.
  - Continue maintaining the system.
  - Transform the system by re-engineering to improve its maintainability.
- The strategy chosen should depend on the system quality and its business value.

## System Quality and Business Value



## Legacy System Categories

- Low quality, low business value
  - These systems should be scrapped
- Low-quality, high-business value
  - Should be re-engineered or replaced
- High-quality, low-business value
  - Replace, scrap, or maintain
- High-quality, high business value
  - Continue in operation using normal system maintenance

## Software Maintenance

Managing the processes of system change

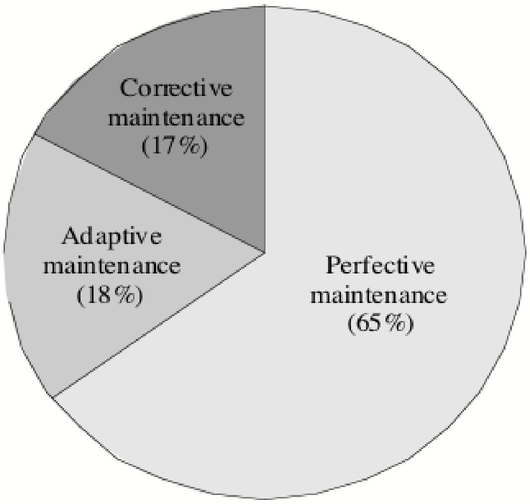
## Maintenance is Inevitable

- The system requirements are likely to change while the system is being developed because the environment is changing.
- When a system is installed in an environment it changes that environment and therefore changes the system requirements.

## Types of Maintenance

- Perfective maintenance
  - Adding or modifying the system's functionality to meet new requirements.
- Adaptive maintenance
  - Changing a system to adapt it to new hardware or operating system.
- Corrective maintenance
  - Changing a system to fix coding, design, or requirements errors.

## Which type of maintenance is the most common one?




## Evolving Systems

- It is usually more expensive to add functionality after a system has been developed rather than design it into the system:
  - Maintenance staff are often inexperienced and unfamiliar with the application domain.
  - Programs may be poorly structured and hard to understand.
  - Changes may introduce new faults as the complexity of the system makes impact assessment difficult.
  - The structure may be degraded due to continual change.
  - There may be no documentation available to describe the program.

## The Maintenance Process

- Maintenance is triggered by change requests from customers or marketing requirements.
- Changes are normally batched and implemented in a new release of the system.
- Programs sometimes need to be repaired without a complete process iteration but this is dangerous as it leads to documentation and programs getting out of step.

## Maintenance Costs

- Usually greater than development costs (2 to 100* depending on the application).
- Affected by both technical and non-technical factors.
- Maintenance corrupts the software structure so makes further maintenance more difficult.
- Aging software can have high support costs, e.g. old languages, compilers etc.

## Maintenance Cost Factors

- Module independence
  - It should be possible to change one module without affecting others.
- Programming language
  - High-level language programs are easier to maintain.
- Programming style
  - Well-structured programs are easier to maintain.
- Program validation and testing
  - Well-validated programs tend to require fewer changes due to corrective maintenance.

## Maintenance Cost Factors

- Documentation
  - Good documentation makes programs easier to understand.
- Configuration management
  - Good CM means that links between programs and their documentation are maintained.
- Application domain
  - Maintenance is easier in mature and well-understood application domains.
- Staff stability
  - Maintenance costs are reduced if the same staff are involved with them for some time.

## Maintenance Cost Factors

- Program age
  - The older the program, the more expensive it is to maintain (usually).
- External environment
  - If a program is dependent on its external environment, it may have to be changed to reflect environmental changes.
- Hardware stability
  - Programs designed for stable hardware will not require to change as the hardware changes.

## How to measure maintainability?

- Control complexity
  - Can be measured by examining the conditional statements in the program.
- Data complexity
  - Complexity of data structures and component interfaces.
- Length of identifier names
  - Longer names imply readability.
- Program comments
  - Perhaps more comments mean easier maintenance.

## How to measure maintainability?

- Coupling
  - How much use is made of other components or data structures.
- Degree of user interaction
  - The more user I/O, the more likely the component is to require change.
- Speed and space requirements
  - Require tricky programming, harder to maintain.

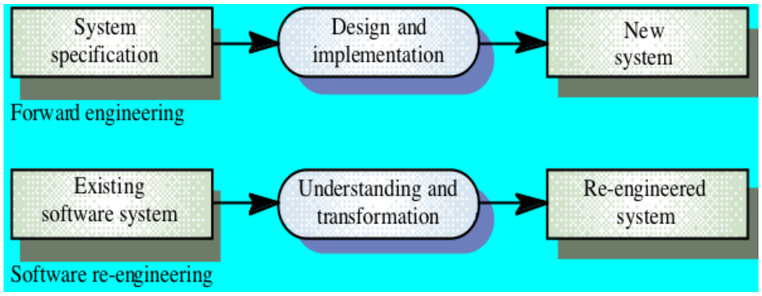
## Process Measurements

- Number of requests for corrective maintenance.
- Average time taken to implement a change request.
- Number of outstanding change requests.
- If any or all of these is increasing, this may indicate a decline in maintainability.

## Software Re-Engineering

Reorganizing and modifying existing software systems to make them more maintainable

## Forward Engineering and Re-Engineering




## When to Re-Engineer

- When system changes are mostly confined to part of the system, then re-engineer that part.
- When hardware or software support becomes obsolete.
- When tools to support re-structuring are available.

## Re-Engineering Advantages

- Reduced risk
  - There is a high risk in new software development.
- Reduced cost
  - The cost of re-engineering is often significantly less than the costs of developing new software.

## Re-engineering Cost Factors

- The quality of the software to be re-engineered.
- The tool support available for re-engineering.
- The extent of the data conversion which is required.
- The availability of expert staff for re-engineering.

## Reverse Engineering

- Reverse Engineering is the process of determining how a system works by analyzing its internal constituents and/or its external behaviour.
- In the software world one would say that reverse engineering is trying to figure out how a system works by:
  - Inspecting the source code and documentation (if it exists)
  - Exercising the executable programs and observing their behavior.

## Why is Reverse Engineering Important/Necessary?

- Most software that is developed is not “from scratch”.
- Understanding someone else’s source code, specifications, designs, is difficult.
  - Why is this so?
  - What makes software more difficult to understand than a toaster or a car?

## Software Maintenance Problem

- A company hires a bright software developer to maintain a system.
- The project manager points the developer to a source code directory and says “become an expert in the system as soon as possible”.
- The IBM TOBEY back-end compiler project allowed for a 1 year learning curve (but this is quite rare).

## Reverse Engineering Research

- The focus has been primarily on the development of tools to help software developers understand software quicker and with less effort.
- Not much work has been done on reverse engineering methods, however.

## Sherlock Holmes Analogy

by Spiros Mancoridis

*We have developed good detective tools (e.g., magnifying glasses, fingerprint matchers, etc) but we have little insight on how to train someone to be a good detective (e.g., guidelines, processes, etc)*

## Progress Has Been Made In ...

- Source code analysis
- Program tracing and profiling
- Automatic modularization (software clustering)
- But still a research area in its infancy ...

## Lecture schedule

- Sep 6 & 11: Introduction, administrivia
- Sep 18 & 20: Static and dynamic analysis
- Sep 25 & 27: Software clustering
- Oct 2 & 4: Evaluation of clustering techniques
- Oct 9 & 11: Introduction to Design Patterns
- Oct 16 & 18: Design Pattern Detection
- Oct 23 & 25: Refactoring
- Oct 30 & Nov 1: No classes (WCRE conference)
- Nov 6 & 8: Program Transformation
- Nov 13 & 15: Re-Engineering Patterns
- Nov 20 & 22: Research paper presentations
- Nov 27 & 29: Research paper presentations

## Grading

- 10% - Participation (paper discussion)
- 20% - Assignment
- 30% - Research paper presentation
- 40% - Project report

## Workload

- September: 2 papers a week
- October: Assignment + 2 papers a week
- November: 1 paper to present + project