CH11: Maintaining the System

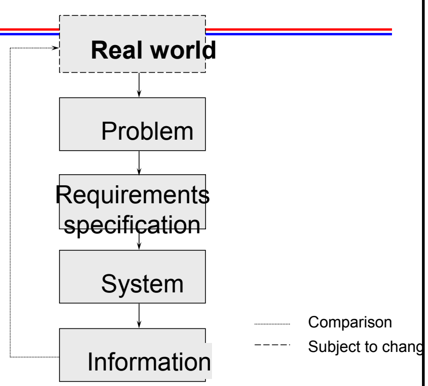
- maintenance process can be difficult
- * The Changing System
- * The Nature of Maintenance
- * Maintenance Problems
- * Measuring Maintenance Characteristics
- * Maintenance Techniques and Tools
- * Software Rejuvenation

TECH
Computer Science

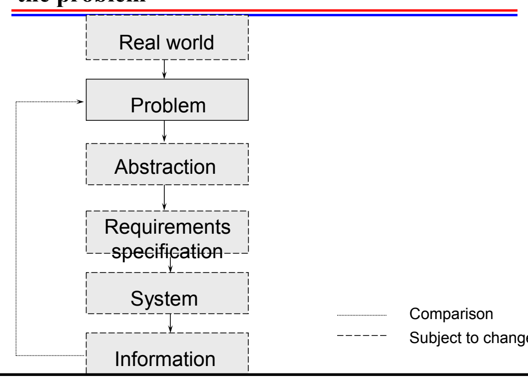
The Changing System

- Any work done to change the system after it is in operation is considered to be **maintenance**.
- Unlike hardware, software does not degrade or require periodic maintenance (?).
- Types of Systems:
  - **S, P, E**

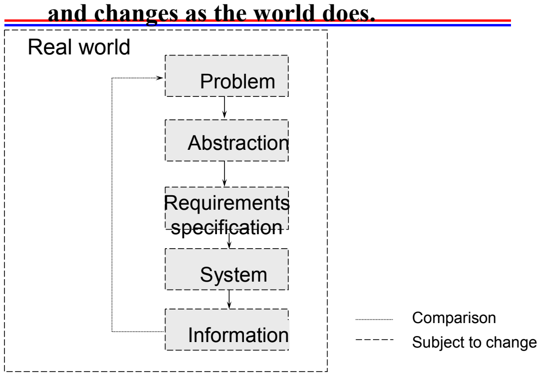
S-System: the solution of the problem is well-know



P-System: based on a practical abstraction of the problem



E-System: embedded in the real world and changes as the world does.



Change During the System Life Cycle

- Everything Change
- Take change into consideration during system development.
- Make it easier to change during maintenance

The System Life Span

- Is it possible to build a system right the first time?
- Maintenance state of development is the evolutionary phase of the system.
- **Legacy systems** were built earlier when our needs and environment were different.

Development Time vs. Maintenance Time

- Typical development project takes between 1 and 2 years, but
- requires an additional 5 to 6 years of maintenance time!
- 80-20 Rule: Twenty percent of the effect is in development and eighty percent is in maintenance.

System Evolution vs. System Decline: When shall we discard the old system and build a new one to replace it?

- **Is the cost of maintenance too high?**
- **Is the system reliability unacceptable?**
- **Can the system no longer adapt to further change, and within a reasonable amount of time?**
- **Is system performance still beyond prescribed constraints?**
- **Are system functions of limited usefulness?**
- **Can other systems do the same job better, faster, or cheaper?**
- **Is the cost of maintaining the hardware great enough to justify replacing it with cheaper, newer hardware?**

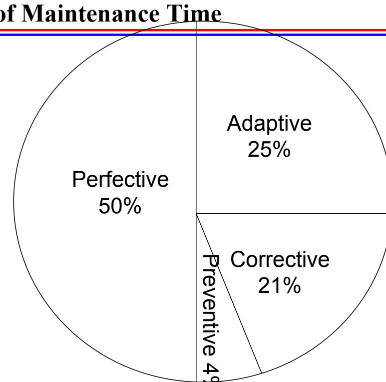
"Laws of Software Evolution"

- **Continuing change: changing till replacing by recreated version**
- **Increasing complexity: structure deteriorates and complexity increases**
- **Fundamental law of program evolution: subjected to self-regulating with statistically-determinable trends and invariances.**
- **Conservation of organizational stability (invariant work rate): rate in a programming project is statistically invariant.**
- **Conservation of familiarity (perceived complexity): release content of the successive releases is statistically invariant.**

The Nature of Maintenance

- Corrective Maintenance: maintenance in respond to problems resulting from faults during day-to-day system usage.
- Adaptive Maintenance: a change introduced in one part of the system requires changes to other parts.
- Perfective Maintenance: make changes to improve some aspect of the system
- Preventive Maintenance: make change to prevent failures.

Use of Maintenance Time



Maintenance Problems

- How do we balance the need for change with the need for keeping a system accessible for users?
- Staff Problems
- Technical Problems
- The Need to Compromise
- Maintenance Cost

Staff Problems

- Limited Understanding: 47% of software maintenance effect is devoted to understanding the software to be modified.
- User's Limited Understanding: provide incomplete and misleading data when reporting a problem
- Management Priorities: view maintaining and enhancing as more (or less?) important then building new applications

Staff Problems: Morale

- 11.9% of the problems during maintenance result from low morale and productivity.
- During maintenance, 8% of the problems result from a programmer's being pulled in too many directions at one, and thus being unable to concentrate on one problem long enough to solve it.

Technical Problems

- **Number one problem!** The y2k problem, "year 2000 problem," is a good example of where simple but narrow design decisions can have a major effect on maintenance.
- Maintaining object-oriented programs can be problematic: the design often involves components that are highly interconnected by complex inheritance schemes.

More Technical Problems

- Inadequate design specifications and low-quality programs and document account for almost 10% of maintenance effort.
- Testing Difficulties: Testing the system in used can be a problem.
  - **Solution: tests are often run on duplicate system**

The Need to Compromise

- Programmer may be forced to compromise elegance and design principles because a change is needed immediately.
- The team is forced to concentrate is resources on a problem about which it may have little understanding.

Maintenance Cost

- All the problems of maintaining a system contribute to the high cost of software maintenance.
- Maintenance costs may be up to **80%** of a system's lifetime costs.
  - **A series of repairs and enhancements usually leads to fragmentation of system, poor document, ... -> more difficult and more effort needed for future maintenance.**
  - **Staff Specialization: leads to exponential increase in resources devoted to maintenance.**

Measuring Maintenance Characteristics

- External view of maintainability: records the following info for each problem
  - **the time at which the problem is reported**
  - **any time lost due to administrative delay**
  - **the time required to analyze the problem**
  - **the time required to specify which changes are to be made**
  - **the time needed to make the change**
  - **the time needed to test the change**
  - **the time needed to document the change**

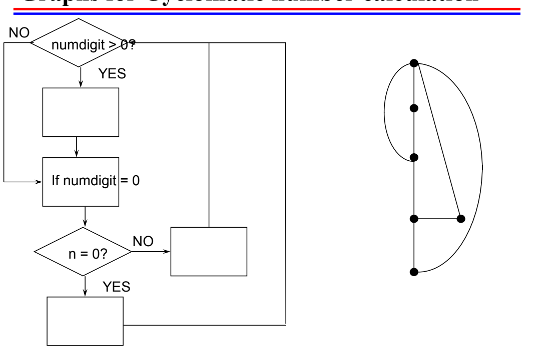
Internal Attributes Affecting Maintainability

- the more complex the code, the more effort required to maintain it
- measuring how complex:
- **Cyclomatic Number** is a metric that captures an aspect of the structure complexity of source code by measuring the number of linearly independent paths through the code.

Finding the Cyclomatic number

- = edges - nodes + 2
- = number of separated segments in the graph
- = number of decision statements in the code + 1
- Cautions:
  - **there are other attributes that contribute to complexity that are not captured by its structure**

Graphs for Cyclomatic number calculation



CONTROL FLOW GRAPH   EQUIVALENT GRAPH

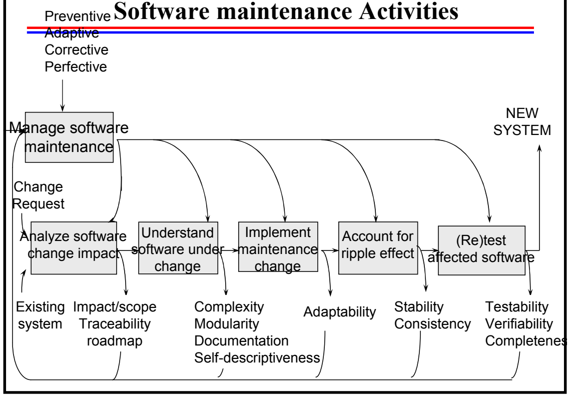
Readability

- Text: ~= number of years of schooling needed for a person to read a passage with ease and understanding
- Fog Index = 0.4 * number of words / number of sentences + percentage of words of 3 or more syllables
- Software: **Readability of source code** = 0.295*(average normalized length of variables) - 0.499*(number of lines containing statements) + 0.13*(Cyclomatic number)

Maintenance Techniques and Tools

- **Configuration Management** keeps track of changes and their effects on other system components.
- **Impart analysis** is the evaluation of the many **risks** associated with the change, including estimates of effects on resources, effect, and schedule.

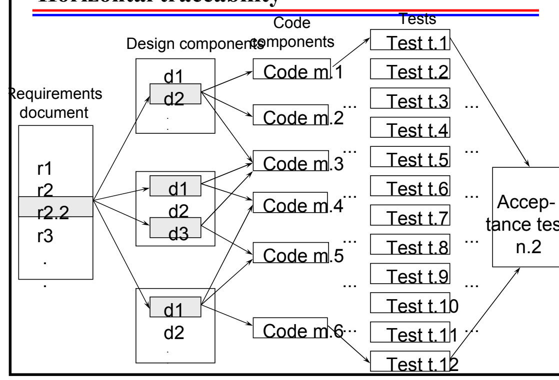
Software maintenance Activities



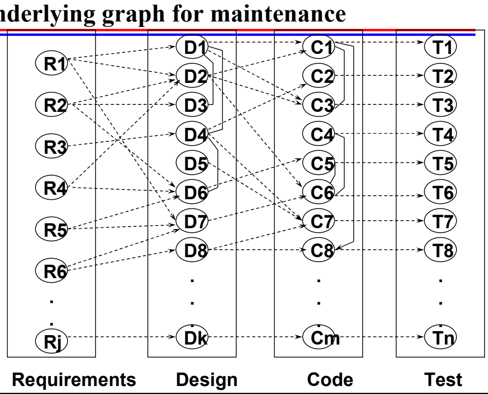
Workproducts and Traceability

- A workproduct is any development artifact whose change is significant.
- Vertical traceability expresses the relationship among the parts of the workproduct.
- Horizontal traceability addresses the relationships of the components across collections of workproducts.

Horizontal traceability



Underlying graph for maintenance



Complexity as result of maintenance

- If the number of paths in the graph increase after the change,
- then the system is likely to be more unwieldy and difficult to maintain.
- If number edges go into the node (in-degrees) and number of edges go out the node (out-degrees) increase substantially,
- then the system may be harder to maintain in the future.

Tools for Maintenance

- Text Editors
- File Comparator
- Compilers and Linkers
- Debugging Tools
- Cross-reference Generators
- Static Code Analyzers
- Configuration Management repositories

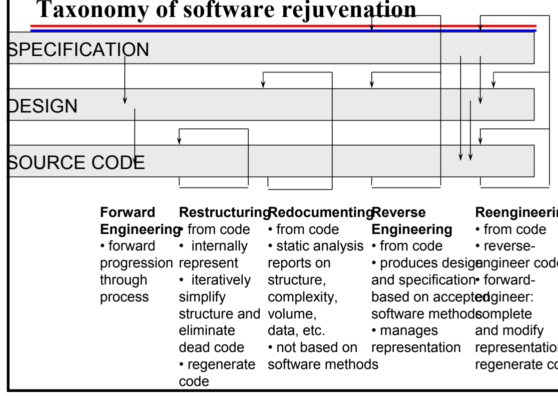
Software Rejuvenation

- addresses maintenance challenge by trying to increase the overall quality of an existing system
- Redocument: analysis of the source code to provide more info to assist maintenance.
- Restructure: transforming ill-structured code into well-structured one.

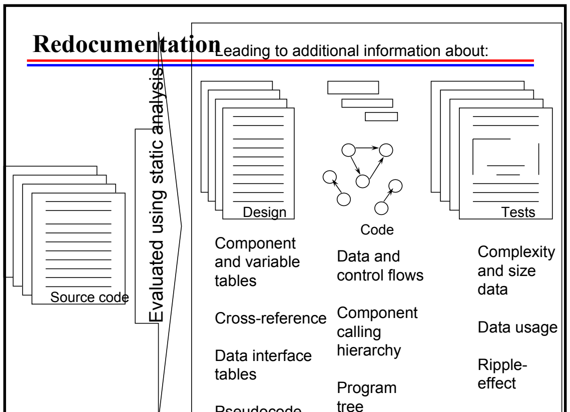
Reverse engineer

- Reverse engineer: recreating design and specification information from the code.
- Reengineering: reverse engineer then “forward engineer” to change the specification and design

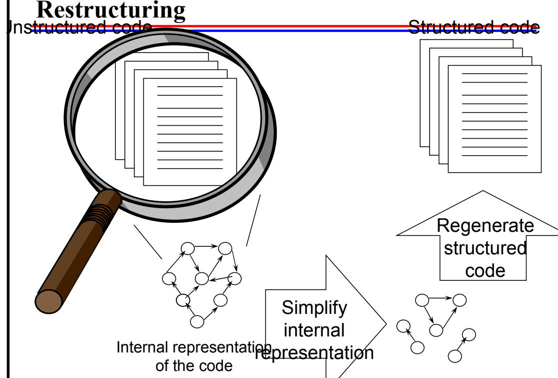
Taxonomy of software rejuvenation



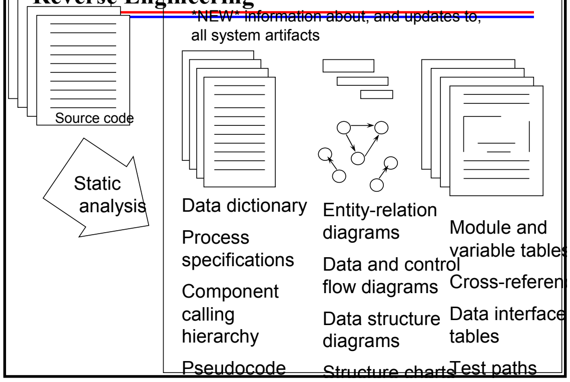
Redocumentation



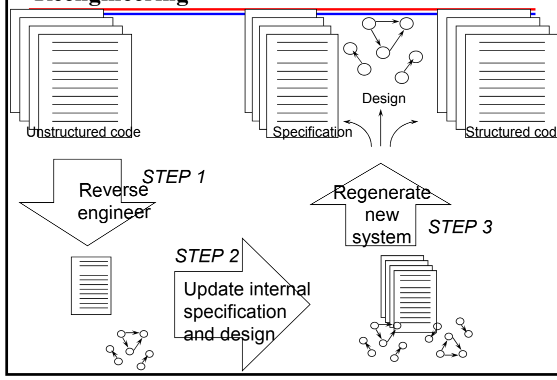
Restructuring



Reverse Engineering



Reengineering



Concluding Remark: What this course means for you

- Software development processes
- Large software projects
- Team Work
- Documentation and communication
- Learn the terms of the trade
- What to expect when you work in software development co. ($$$) (???)

•"Live Long and Prosper"