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Today's Agenda

- Software Maintenance

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Software Maintenance

- Introduction
- Process Models
- Program Understanding
- Configuration Management
- Management Issues
- Conclusion

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Software Maintenance

- Management and control of changes to a software product after delivery
  - Bug fix, new features, environment adaptation, performance improvement
- Often accounts for 40-70% of the cost of the entire life-cycle of a software product
  - The more successful a software product is, the more time it spends on maintenance

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Software vs Programs

Software Components	Examples	
Program	1. Source code 2. Object code	
Documentation	1. Analysis/Specification	(a) Formal specification (b) Data flow diagrams
	2. Design	(a) High-level design (b) Low-level design (b) Data model
	3. Implementation	(a) Source code (b) Comments
	4. Testing	(a) Test design (b) Test results
Operating Procedures	1. Installation manual 2. User manual	

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Maintenance vs Development

- Maintenance must work within the parameters and constraints of an existing system
  - The addition of a new room to an existing building can be more costly than adding the room in the first place
- An existing system must be understood prior to a change to the system
  - How to accommodate the change?
  - What is the potential ripple effect?
  - What skills and knowledge are required?

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Why Maintenance?

- To provide continuity of service
  - Bug fixing, recover from failure, accommodating changes in the environment
- To support mandatory upgrades
  - Government regulations, maintaining competitive edges
- To support user requests for improvements
  - New features, performance improvements, customization for new users
- To facilitate future maintenance work
  - Re-factoring, document updating

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A Maintenance Framework

- User Requirements
  - Error correction, new features
- Environment
  - Operational: Innovations in hardware and software
  - Organizational: Policy changes, competition
- Maintenance Process
  - Different maintenance process models
- Software
  - Maintainability, complexity, quality of documentation
- Maintenance personnel
  - Staff turnover, domain expertise

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Lehman's Laws

- Law of continuing change: systems must be continually adapted
- Law of increasing complexity: as a system evolves, its complexity increases unless work is done to maintain or reduce it
- Law of continuing growth: functionality must be increased continually to maintain user satisfaction
- Law of declining quality: system quality will appear to decline unless rigorously adapted

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Software Change

- Corrective change: triggered by defects in the software
  - Residual errors in design and/or coding
- Adaptive change: driven by the need to accommodate modifications in the environment
  - Innovations in hardware/software, changes in business rules
- Perfective change: undertaken to expand the existing requirements
  - Enhancement of functionality, improvement in computational efficiency
- Preventive change: undertaken to prevent malfunctions or to improve maintainability
  - Code restructuring, optimization and documentation updating

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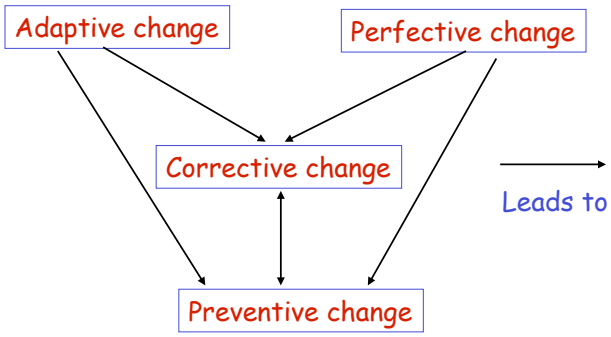
Interplay of changes



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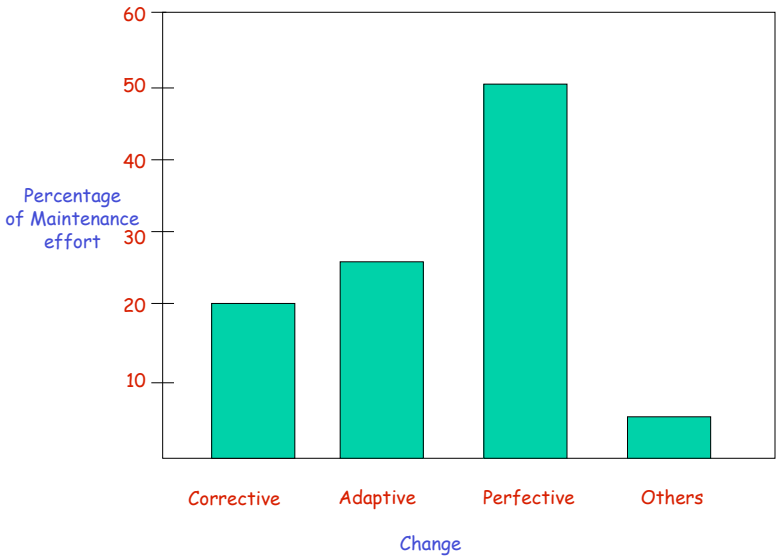
Expenditure on Different Changes

30 : 70
Devel : maintenance



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Major Activities

- Change identification
  - What to change, why to change
- Program understanding
  - How to make the change, what is the ripple effect
- Carrying out the change and testing
  - How to actually implement the change and ensure its correctness
- Configuration management
  - How to manage and control the changes
- Management issues
  - How to build a team

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Development Models

- Code-and-Fix
  - Ad-hoc, not well-defined
- Waterfall
  - Sequential, does not capture the evolutionary nature of software
- Spiral
  - Heavily relies on risk assessment
- Iterative
  - Incremental, but constant changes may erode system architecture

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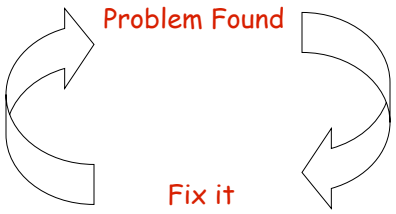
Quick-Fix Model



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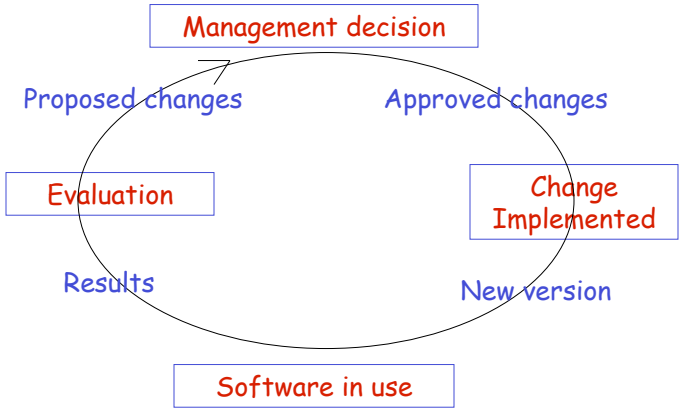
Boehm's Model



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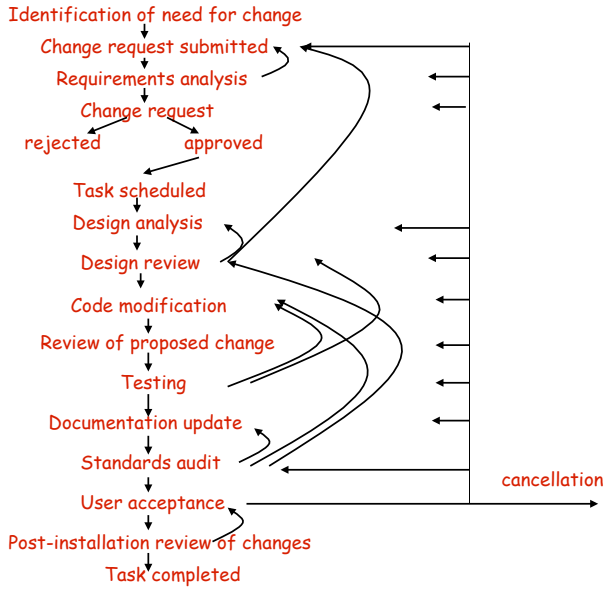
Osborne's Model



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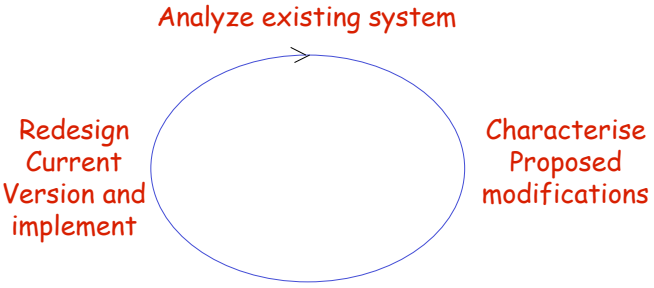
Iterative Enhancement Model



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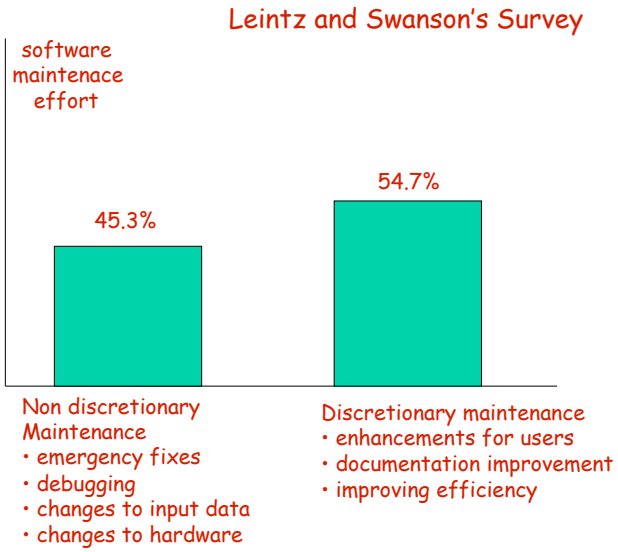
Maintenance Effort (1)



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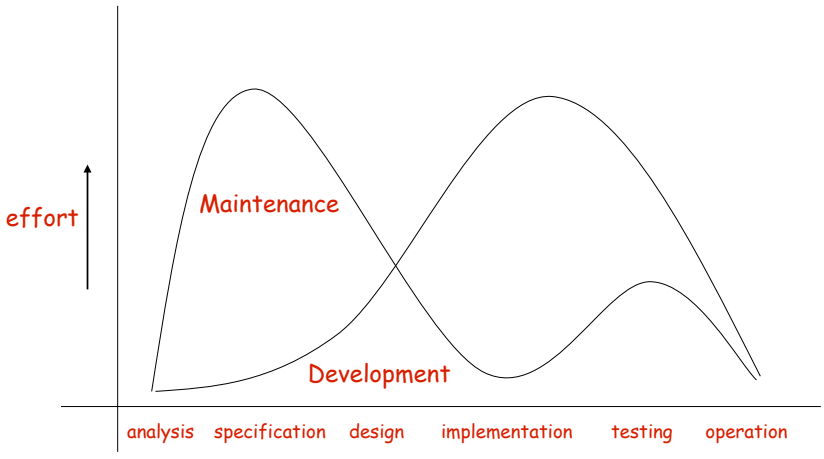
Maintenance Effort (2)



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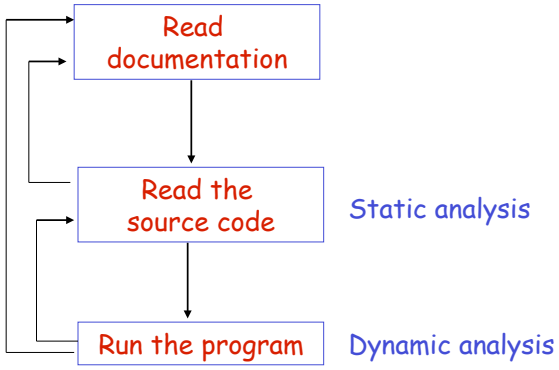
What to understand

- Problem Domain
  - Capture necessary domain knowledge from documentation, end-users, or the program source
- Execution Effect
  - Input-output relation, knowledge of data flow, control flow, and core algorithms
- Cause-Effect Relation
  - How different parts affect and depend on each other
- Product-Environment Relation
  - How the product interacts with the environment

Comprehension Process (1)



Comprehension Process (2)

- Knowledge base: expertise and background knowledge
- Mental model: encodes the current understanding
- Assimilation: obtain information from various sources

Comprehension Strategies

- Top-down: start with the big picture, and then gradually work towards understanding the low-level details
- Bottom-up: start with low-level semantic structures, and then group them into high-level, more meaningful structures
- Opportunistic: A combination of top-down and bottom-up

Factors affecting understanding

- Expertise: Domain knowledge, programming skills
- Program structure: modularity, level of nesting
- Documentation: readability, accuracy, up-to-date
- Coding conventions: naming style, design patterns
- Comments: quality, shall convey additional information
- Program presentation: good use of indentation and spacing

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Reverse Engineering

- The process of analyzing the source code to create system representations at higher levels of abstraction
- Three types of abstraction
  - Function abstraction: what it does, instead of how
  - Data abstraction: abstract data type
  - Process abstraction: communication and synchronization between different processes

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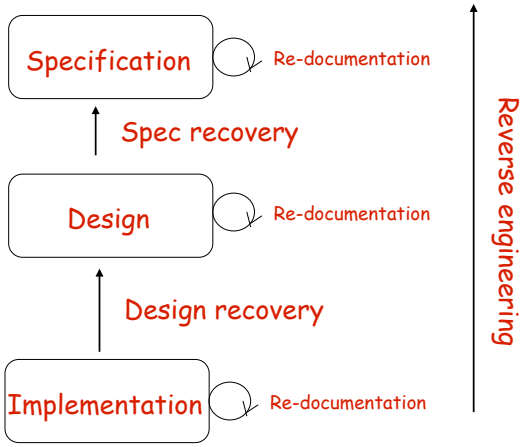
Why RE?

- Allow a software system to be understood in terms of what it does, how it works and its architectural representation
  - Recover lost information
  - Facilitate migration between platforms
  - Improve or provide documentation
  - Provide alternative views
  - Extract reusable components
  - Cope with complexity

Levels of RE



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Why CM?

- Critical to the management and maintenance of any large system
  - Suppose that a customer reports a bug. Without proper control, it may be impossible to address this problem. (Why?)
  - CM allows different releases to be made from the same code base
  - CM also allows effective team work, auditing, and accounting

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Major activities

- Identification of components and changes
- Control of the way changes are made
- Auditing changes – making the current state visible
- Status accounting – recording and documenting all activities that have taken place

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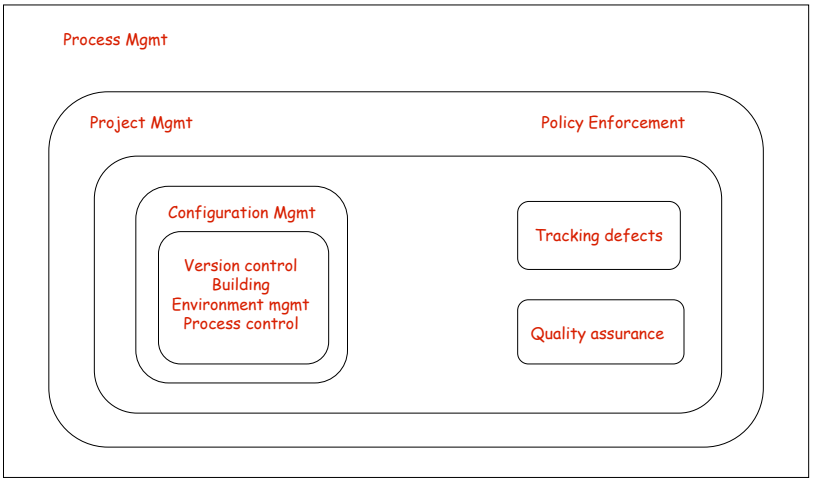
The Big Picture



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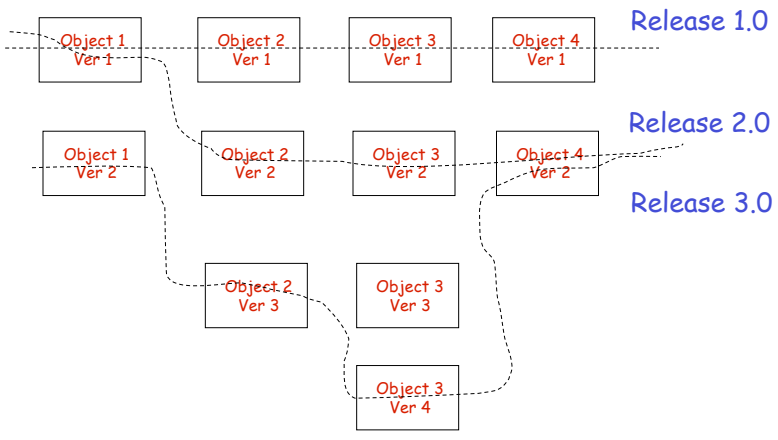
Version Control (1)



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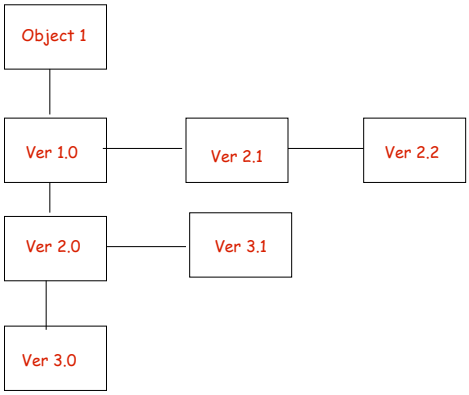
Version Control (2)



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Building

- One of the most frequently performed operations
- Incremental building: only rebuild objects that have been changed or have had a dependency change
- Consistency: must use appropriate versions of the source files
- Makefiles are often used to declare dependencies between different modules

Change Control

- Decide if a requested change should be made
  - Is it valid? Does the cost of the change outweigh its benefit? Are there any potential risks?
- Mange the actual implementation of the change
  - Allocate resources, record the change, monitor the progress
- Verify that the change is done correctly
  - Ensure that adequate testing be performed

Change Request Form

Name of system:
Version:
Revision:
Date:
Requested by:
Summary of change:
Reasons of change:
Software components requiring change:
Documents requiring change:
Estimated cost:

Documentation

- User Doc: Describe system functions without reference their implementation
  - Installation manual, user manual, reference manual, admin manual, etc.
- System Doc: System description from the developer's perspective
  - Requirements, specification, high-level/low-level design, test plans

Producing Quality Documentation

- Writing style: adhere to guidelines, be clear
- Adhering to document standards
- Standards and quality assessment
  - For example, documents need to be reviewed and signed off
- Maintaining consistency
  - Design documents should be consistent with actual implementation code
  - Documents that reference each other should be consistent

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Responsibilities

- Maximize productivity
  - Personnel management
    - Choose the right people, motivate the team, keep the team informed, allocate adequate resources
  - Organizational mode
    - Combined or separate maintenance teams, module ownership, change ownership, work-type or application-type

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Motivating the Team

- Rewards: financial rewards, promotion
- Supervision: technical supervision and support for inexperienced staff
- Assignment patterns: rotate between maintenance and development
- Recognition: properly acknowledge one's achievements
- Career structure: provide room for career growth

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Education and Training

- Objective: To raise the level of awareness
  - Not a peripheral activity, but at the heart of an organization
- Strategies
  - University education
  - Conferences and workshops
  - Hands-on experience

Module Ownership

- Pros
  - The module owner develops a high level of expertise in the model
- Cons
  - No one is responsible for the entire system
  - Workload may not be evenly distributed
  - Difficult to implement enhancements due to unknown dependencies

Change Ownership

- Pros:
  - Tends to adhere to standards set for the entire software system
  - Integrity of the change is ensured
  - Changes can be code and tested independently
  - Changes inspection tends to be taken seriously
- Cons:
  - Training of new personnel can be difficult
  - Individuals do not have long-lasting responsibilities

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Conclusion

- Maintenance a critical stage in the software lifecycle, and must be managed carefully
- Unlike new development, maintenance must work within the constraints of the existing system
- Central to maintenance is the notion of change. Changes must be managed and controlled properly.
- Not only the code needs to be maintained, but also the documentation.