

Software Evolution

Chapter 9 (abridged)

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Software Evolution in the textbook

1. Introduction
 - Importance and overview
2. Evolution processes (9.1)
 - Change processes for software systems.
3. Software maintenance (9.3)
 - Types and costs
 - Maintenance prediction
 - Software reengineering and refactoring

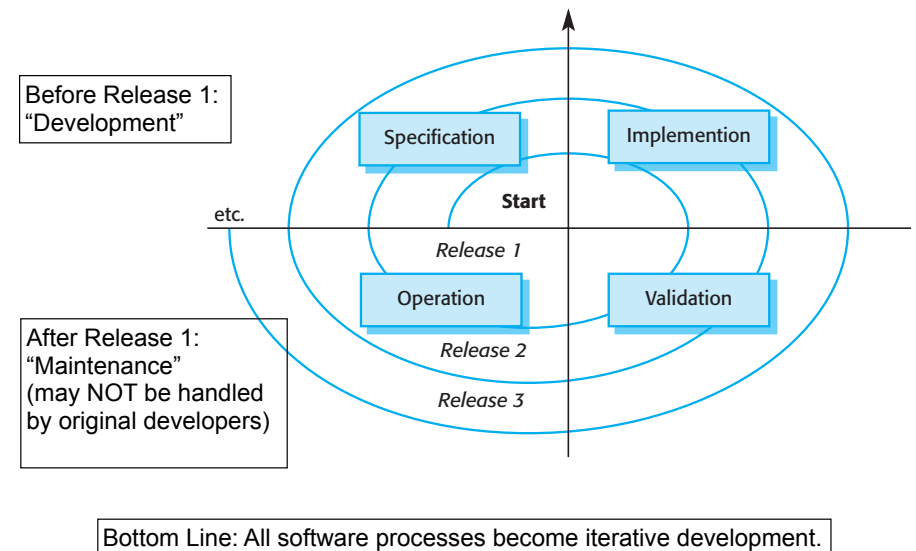
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Importance of evolution

- Software systems are critical and costly business assets.
- Software must be changed/updated to maintain its value
- Goal: use software many years to get return on investment
 - Air traffic control: 30 years
 - Business systems: 10 years
- Large companies spend more on changing existing software than developing new software.

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Overview of software evolution



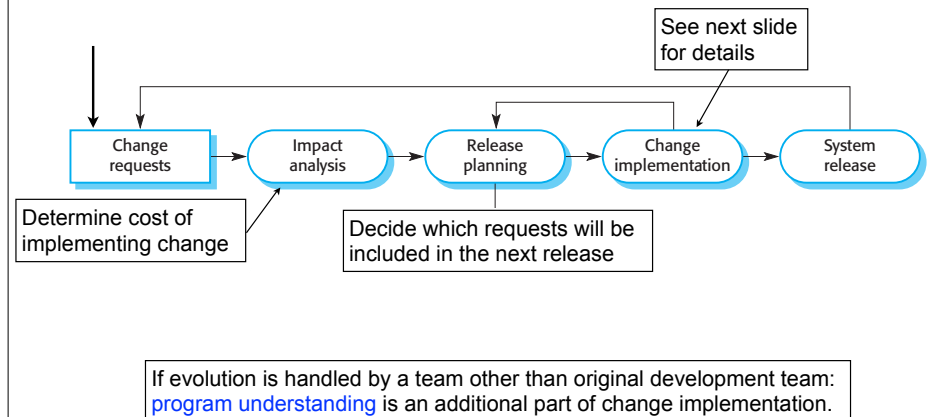
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2 Evolution processes

- Software evolution processes depend on
 - The type of software being maintained
 - The development processes used
 - The skills and experience of the people involved.
- Process may be informal or formal
- Proposals for change are the driver for system evolution.
 - requests for new features
 - bug reports
 - ideas for improvements

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The software evolution process:



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Change implementation: steps

- Modify Requirements
 - Analysis
 - Update specifications
 - Validation
- Program understanding, as needed
- Modify Design
 - Update design documents and/or models
- Modify Implementation
 - Modify source code
- Re-Testing

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Urgent change requests

- Sources of urgent changes
 - Defect somehow blocking normal operation
 - Changes to the system's environment (e.g. OS upgrade)
 - Business changes requiring rapid response (e.g. the release of a competing product).
- May not be able to follow formal change process
 - Quick and dirty code change
 - Minimal testing
- Problem:
 - Code quality is diminished
 - Specs and code are now inconsistent
- Should: follow formal process later.

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3. Software maintenance

- Modifying a program after it has been put into use.
- The term is often applied to cases where a separate development team takes over after delivery.
 - Otherwise it's just iterative development
- Modifications may be simple or extensive
 - But NOT normally involving major changes to the system's architecture.

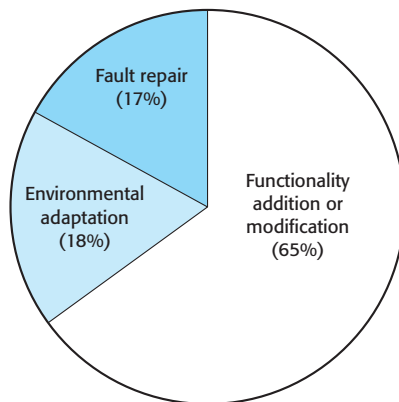
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Types of maintenance

- Repairing software faults
 - Changing a system to correct coding, design, or requirements errors.
- Adapting software to a different operating environment
 - Changing a system so that it operates with a modified external system (e.g. new OS, or other software).
- Adding to or modifying the system's functionality
 - Modifying the system to satisfy new requirements.

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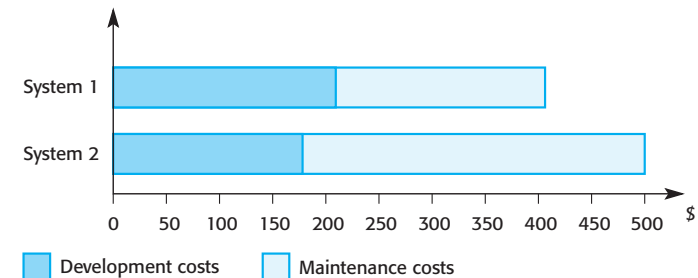
Maintenance effort distribution



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Development and maintenance costs

“A stitch in time saves nine”



In system 1, extra development costs are invested in making the system more maintainable, effectively reducing overall costs.

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Maintenance cost factors

why adding new functionality after delivery costs even more

- Team stability
 - New team members take time to learn the system.
- Poor development practice
 - The developers of a system may have no incentive to write maintainable software if they won't be maintaining it.
- Staff skills
 - Maintenance staff are often inexperienced and have limited domain knowledge.
- Program age and structure
 - As programs age, (without refactoring) their structure is degraded--they become harder to understand and change.

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Maintenance prediction

- Estimating the overall maintenance costs for a system in a given time period (for planning purposes)
- Studies have shown that
 - Most maintenance effort is spent on a relatively small number of system components.
 - The more complex a component, the more expensive it is to maintain.
- Software metrics
 - Measure of a piece of software, to determine complexity
 - Lines of code, program size, number of objects, methods, etc.
 - cyclomatic complexity: number of execution paths through code

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Software reengineering

- Problem: Many older systems are difficult to understand and change.
 - May have been optimized for performance or space.
 - Structure may have been corrupted by series of changes
 - May have been poorly designed or commented
- Solution: Reengineering
 - Re-structuring or re-writing part or all of a software system without changing its functionality.
 - The system may be re-structured and re-documented to make it easier to maintain.

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Software reengineering: Why not just rewrite from scratch?

- Reengineering takes less time
 - Developing a new system almost always takes longer than expected.
 - Re-developing a system involves duplicating work that has already been done for the existing system.
 - No matter how bad the old system is, it can probably be greatly improved in less time than starting over again from scratch.
- There is no guarantee the new system would be better.
- Joel on Software: Things you should never do
<http://www.joelonsoftware.com/articles/fog0000000069.html>

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Software reengineering techniques

- **Regression Testing**
 - To ensure modifications don't change functionality.
- **Source code translation**
 - If it needs to be in a new language
- **Reverse engineering**
 - Analyzing source code to determine its design/structure
 - This does not change the code, but produces documentation.
- **Program restructuring**
 - Reorganize control structures and functions for understandability
- **Data reengineering**
 - Clean-up and restructure system data.

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Preventative maintenance by refactoring

- **Refactoring is: changing a software system: altering its internal structure without changing its external behavior**
 - To improve readability.
 - To improve structure.
 - Reduce complexity.
 - Bottom line: easier to modify in the future
- **No added functionality**
- **Preventative maintenance: reduces future maintenance costs**

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Refactoring versus Reengineering

- **Both alter the code without altering functionality, with the purpose of making code more maintainable.**
- **Reengineering**
 - Takes place after system is in use.
 - Applied when maintenance costs are too high.
 - Often involves running automated tools on legacy code.
- **Refactoring**
 - Ongoing process, from start of development
 - Applied on smaller scale
 - Avoids structure degradation from the start

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Where to apply refactoring (bad smells)

- **Duplicate code**
 - Same or very similar code found at various places in a program.
 - Extract method: put similar code into a single method/function
- **Long method**
 - Long methods are difficult to understand, modify.
 - Redesign as many shorter methods
- **Switch (case) statements**
 - Multiple switch statements with same cases.
 - Make subclasses, move each case into appropriate subclass.
- **Data clumping**
 - The same group of items occur in several places in a program.
 - Replace with an object that encapsulates all of the data (struct/obj)
- **Speculative generality**
 - Unused parameters, classes, etc, included "just in case".
 - These can often simply be removed

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Refactoring example

```
class Employee
  double monthlySalary;
  double commission;
  double bonus;
  int getType() { ... }
  int payAmount() {
    switch (getType()) {
      case ENGINEER:
        return monthlySalary;
      case SALESMAN:
        return monthlySalary + commission;
      case MANAGER:
        return monthlySalary + bonus;
      default:
        throw new RuntimeException("Incorrect Employee");
    }
  }
}
```

Note: classes are incomplete:
constructors, getters/setters
are not shown.

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Refactoring example

```
class Employee...
  double monthlySalary;
  double commission;
  double bonus;
  int payAmount();
}
class Engineer : Employee
  int payAmount() {
    return monthlySalary;
  }
class Salesman : Employee
  int payAmount() {
    return monthlySalary + commission;
  }
class Manager : Employee
  int payAmount() {
    return monthlySalary + bonus;
  }
}
```

Move cases into
(new) subclasses

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Refactoring example

```
class Employee... {
  double monthlySalary;
  int payAmount();
}
class Engineer : Employee {
  int payAmount() {
    return monthlySalary;
  }
}
class Salesman : Employee {
  double commission;
  int payAmount() {
    return monthlySalary + commission;
  }
}
class Manager : Employee {
  double bonus;
  int payAmount() {
    return monthlySalary + bonus;
  }
}
}
```

Push down field: when a field is
used only by some subclasses

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