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Chapter 6: Maintainability-Oriented Software Construction Approaches

6.1 Metrics and Construction Principles for Maintainability

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Outline

- **Software Maintenance and Evolution**
- **Metrics of Maintainability**
- **Modular Design and Modularity Principles**
- **OO Design Principles: SOLID**
- **OO Design Principles: GRASP**
- **Summary**

本章面向另一个质量指标：可维护性——软件发生变化时，是否可以以很小的代价适应变化？

本节是宏观介绍：
（1）什么是软件维护；
（2）可维护性如何度量；
（3）实现高可维护性的设计原则——很抽象

Reading

- **软件工程--实践者的研究方法：第23章**
- **Object-Oriented Software Construction：第3章**

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1 Software Maintenance and Evolution

What is Software Maintenance?

- **Software maintenance** in software engineering is the modification of a software product after delivery to correct faults, to improve performance or other attributes. 软件维护：修复错误、改善性能

- In "ISO/IEC 14764:2006 Software Engineering — Software Life Cycle Processes — Maintenance"

Operation & Maintenance Engineer 运维工程师

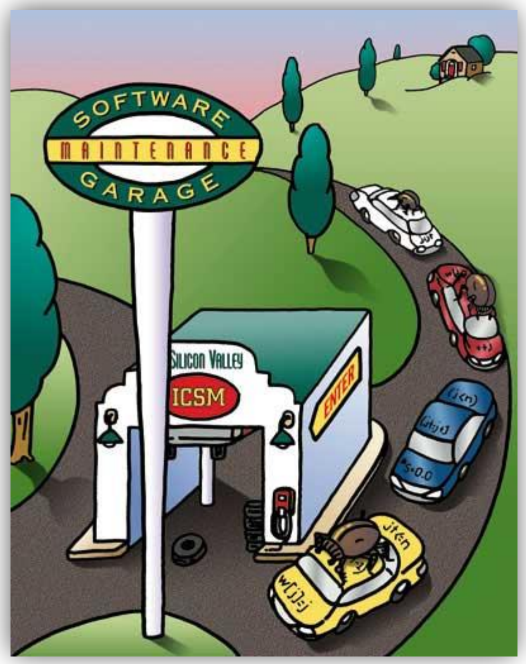
- **Maintenance is one of the most difficult aspects of software production because maintenance incorporates aspects of all other phases 运维是软件开发中最困难的工作之一**
- **A fault is reported from users and is to be handed by a maintenance engineer. 处理来自用户报告的故障/问题**
- **A maintenance engineer must have superb debugging skills**
  - The fault could lie anywhere within the product, and the original cause of the fault might lie in the by now non-existent specifications or design documents (bug/issue localization).
  - Superb diagnostic skills, testing skills and documentation skills are required (testing, fix, and documenting changes).

After fixing the code

- **More Steps:**
  - Test that the modification works correctly: use specially constructed test cases 测试所做的修改
  - Check for regression faults: use stored test data, and add specially test cases to stored test data for future regression testing 回归测试
  - Document all changes 记录变化
- **How to minimize regression faults 除了修复问题，修改中不能引入新的故障**
  - Consult the detailed documentation and make use of constructed test cases.
- **What usually happens: no enough documentation / test cases 最大的问题：修改后没有足够的文档记录和测试**
  - The operation engineer has to deduce from the source code itself all the information needed to avoid introducing a regression fault.

Types of software maintenance

- **Corrective maintenance** **25%** 纠错性
  - Reactive modification of a software product performed after delivery to correct discovered problems;
- **Adaptive maintenance** **21%** 适应性
  - Modification of a software product performed after delivery to keep a software product usable in a changed or changing environment;
- **Perfective maintenance** **50%** 完善性
  - Enhancement of a software product after delivery to improve performance or maintainability;
- **Preventive maintenance** **4%** 预防性
  - Modification of a software product after delivery to detect and correct latent faults in the software product before they become effective faults.



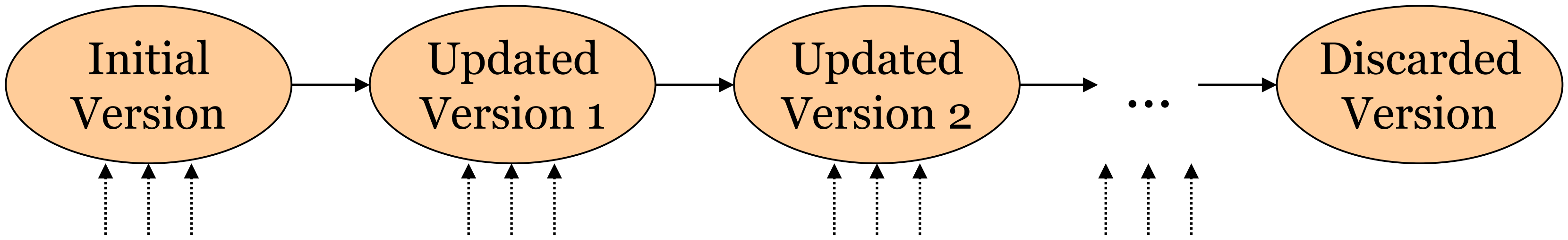
Software Evolution

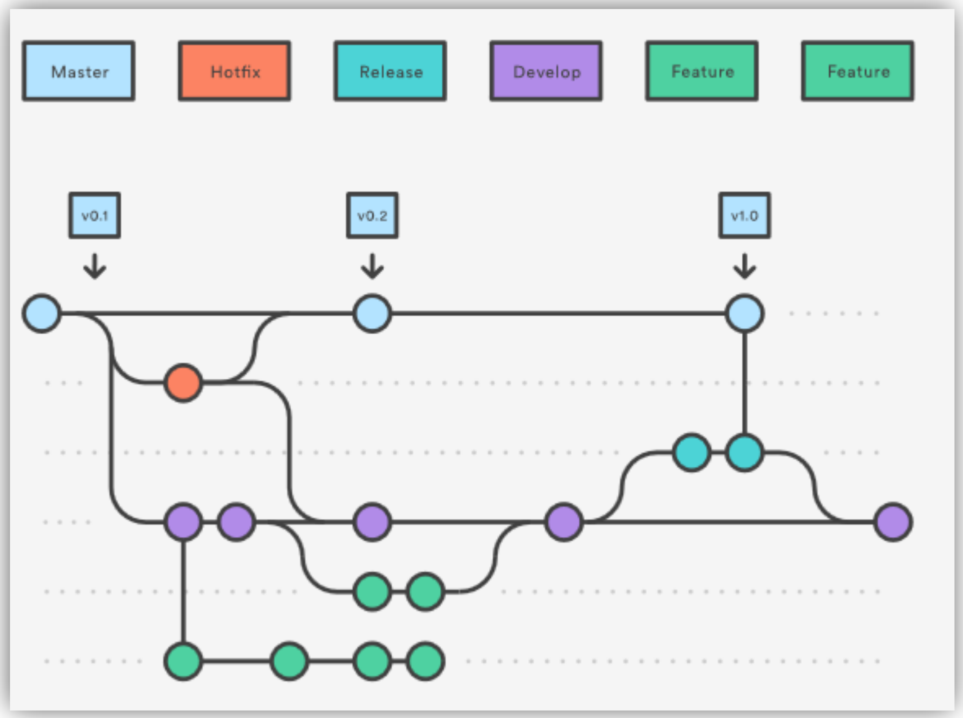
- **Software evolution is a term used in software maintenance, referring to the process of developing software initially, then repeatedly updating it for various reasons. 软件演化：对软件进行持续的更新**

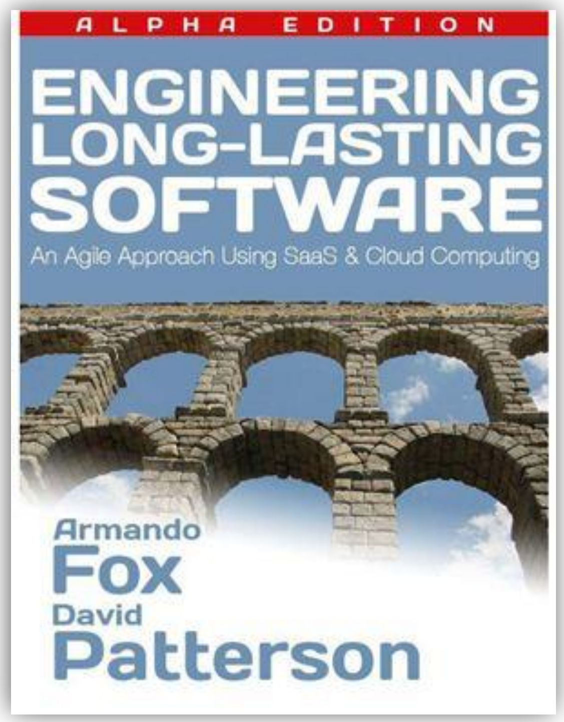
- **Over 90% of the costs of a typical system arise in the maintenance phase, and that any successful piece of software will inevitably be maintained. 软件的大部分成本来自于维护阶段**

Software Evolution

- **Multiple versions in the life of a software: From 1 to *n***






ALPHA EDITION

ENGINEERING LONG-LASTING SOFTWARE

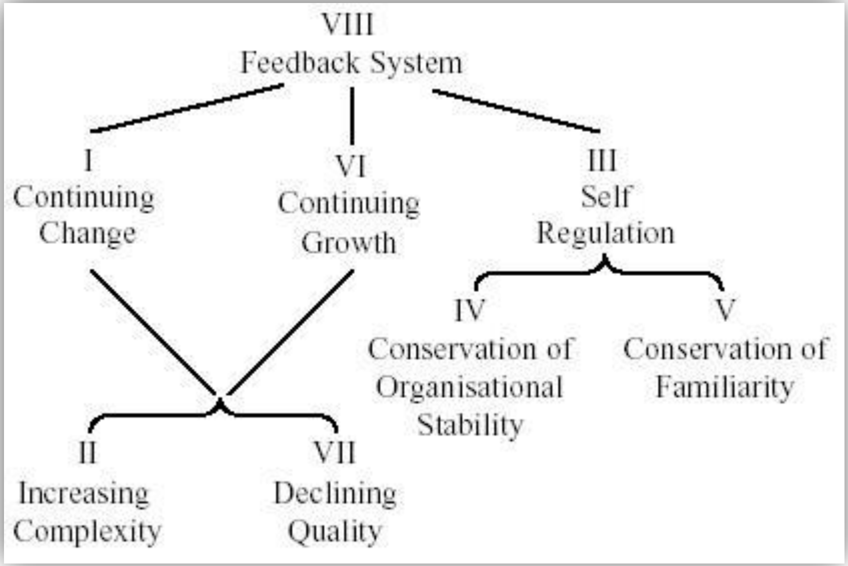
An Agile Approach Using SaaS & Cloud Computing

Armando Fox

David Patterson

Lehman's Laws on Software Evolution

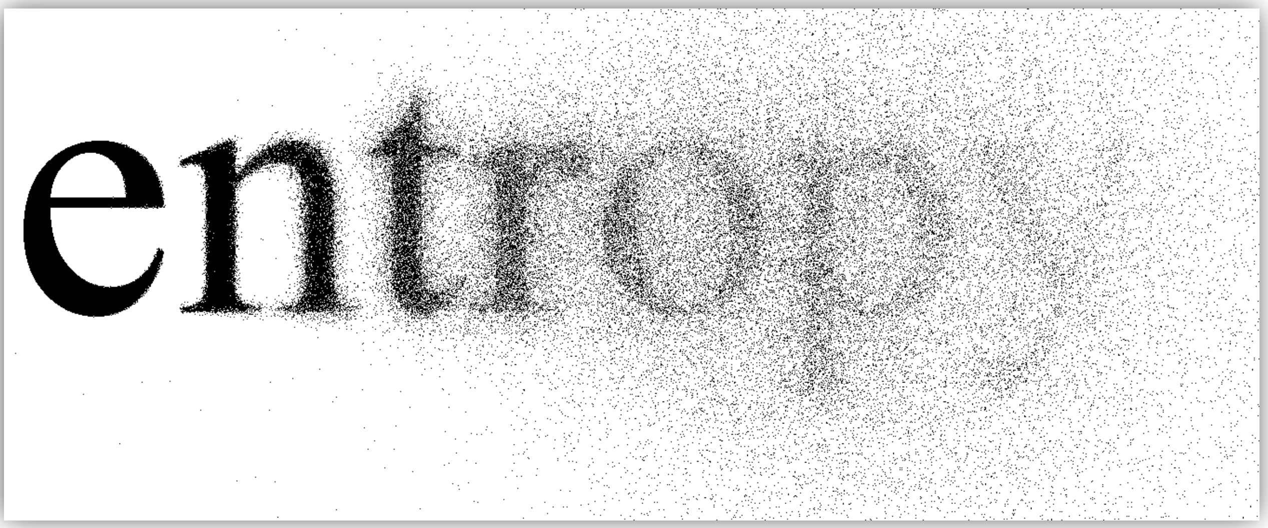
- **Feedback System**
- **Continuing Change**
- **Continuing Growth**
- **Declining Quality**
- **Increasing Complexity**
- **Self Regulation**
  - Conservation of Organizational Stability
  - Conservation of Familiarity



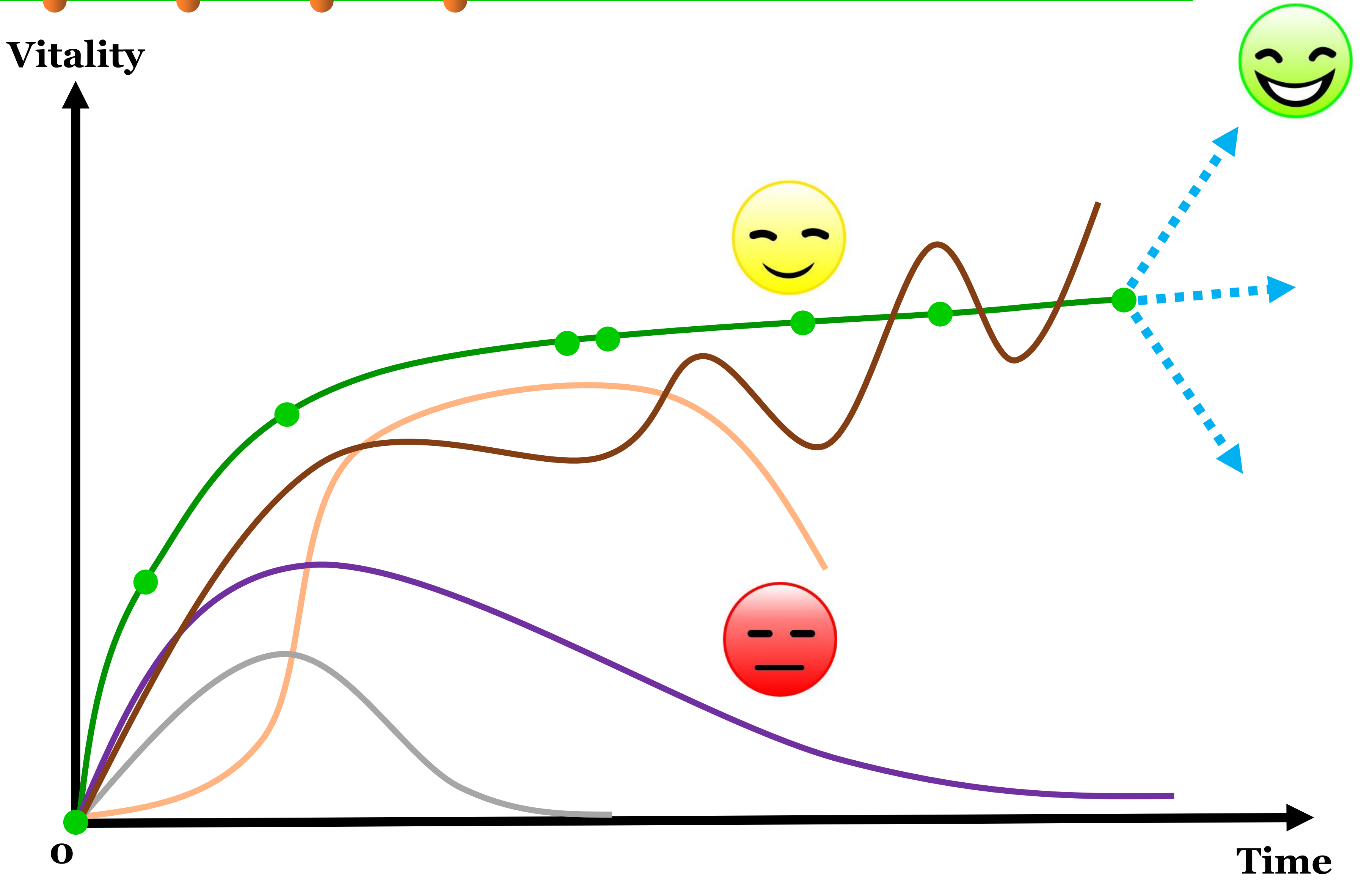
“变化”在软件生命周期中是不可避免的！
如何在最初的设计中充分考虑到未来的变化，避免因为频繁变化导致软件复杂度的增加和质量的下降？

Software Entropy

- **As a system is modified, its disorder, or entropy, tends to increase.**
- **This is known as software entropy.**

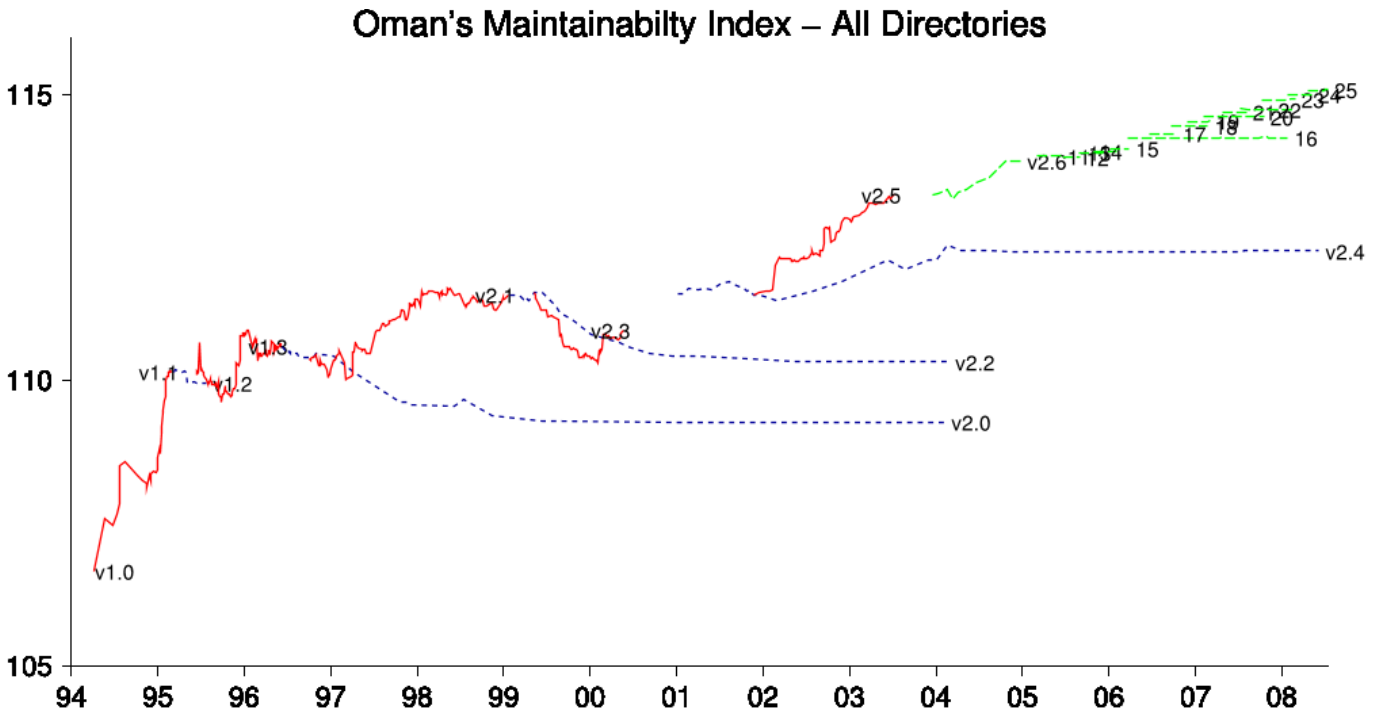


Life patterns of software



Objective of software maintenance and evolution

- **Objective of SW maintenance and evolution: To improve the fitness / adaptability of software, and keep its vitality, i.e., "long-lasting software (low entropy software)" 提高软件的适应性，延续软件生命**
- **An example of Linux Kernel's evolution: its Maintainability Index**



Maintenance is not just the task of op engineers…

- **Maintenance is not just the task of maintenance and operation engineers, but also a potential task of software designers and developers. 软件维护不仅仅是运维工程师的工作，而是从设计和开发阶段就开始了**
- **For them, it is mandatory to consider future potential changes/extensions of the software during the design and construction phases; 在设计与开发阶段就要考虑将来的可维护性**
- **So that flexible and extensible design/constructions are comprehensively considered, in other words, "easy to change / extension". 设计方案的 "easy to change"**
- **This is what's called "maintainability", "extensibility" and "flexibility" of software construction.**

Examples of maintainability-oriented construction

- **Modular design and implementation 模块化**
  - Low coupling and high cohesion 高内聚，低耦合
- **OO design principles OO设计原则**
  - SOLID、GRASP
- **OO design patterns OO设计模式** ☆
  - Factory method pattern, Builder pattern
  - Bridge pattern, Proxy pattern
  - Memento pattern, State pattern
- **State-based construction (Automata-based programming) 基于状态的构造技术** ☆
- **Table-driven construction 表驱动的构造技术** ☆
- **Grammar-based construction 基于语法的构造技术** ☆

These are what to be studied in this chapter

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2 Metrics of Maintainability

Many names of maintainability

Ready for Change
Ready for Extension

- **Maintainability 可维护性** – "The ease with which a software system or component can be modified to correct faults, improve performance, or other attributes, or adapt to a changed environment".
- **Extensibility 可扩展性** – Software design/implementation takes future growth into consideration and is seen as a systemic measure of the ability to extend a system and the level of effort required to implement the extension.
- **Flexibility 灵活性** – The ability of software to change easily in response to user requirements, external technical and social environments, etc.
- **Adaptability 可适应性** – The ability of an interactive system (adaptive system) that can adapt its behavior to individual users based on information acquired about its user(s) and its environment.

Many names of maintainability

- **Manageability 可管理性** —How efficiently and easily a software system can be monitored and maintained to keep the system performing, secure, and running smoothly.

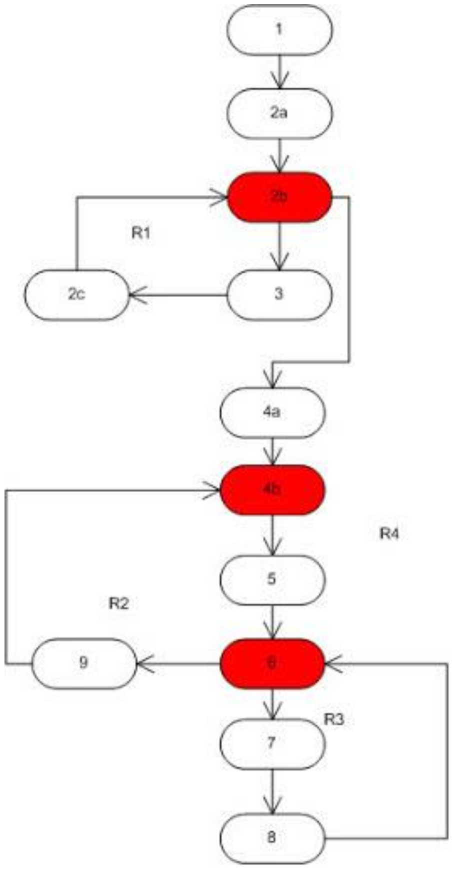
- **Supportability 支持性**—How effectively a software can be kept running after deployment, based on resources that include quality documentation, diagnostic information, and knowledgeable and available technical staff.

Questions about maintainability

- **Code review的时候经常问的关于可维护性的问题：**
  - Structural and design simplicity: how easy is it to change things?
  - Are things tightly or loosely coupled (i.e., separation of concerns)?
  - Are all elements in a package/module cohesive and their responsibilities clear and closely related?
  - Does it have overly deep inheritance hierarchies or does it favor composition over inheritance?
  - How many independent paths of execution are there in the method definitions (i.e., cycolmatic complexity)?
  - How much code duplication exists?
  - …

Some common-used maintainability metrics

- **Cyclomatic Complexity** 圈复杂度 - Measures the structural complexity of the code.
  - It is created by calculating the number of different code paths in the flow of the program.
  - A program that has complex control flow will require more tests to achieve good code coverage and will be less maintainable.
  - CC = E-N+2, CC=P+1, CC=number of areas
- **Lines of Code** 代码行数 - Indicates the approximate number of lines in the code.
  - A very high count might indicate that a type or method is trying to do too much work and should be split up.
  - It might also indicate that the type or method might be hard to maintain.



Some common-used maintainability metrics

For a given problem, Let:

- η_1 = the number of distinct operators
- η_2 = the number of distinct operands 操作数.
- N_1 = the total number of operators
- N_2 = the total number of operands

From these numbers, several measures can be calculated:

- Program vocabulary: $\eta = \eta_1 + \eta_2$
- Program length: $N = N_1 + N_2$
- Calculated program length: $\hat{N} = \eta_1 \log_2 \eta_1 + \eta_2 \log_2 \eta_2$
- Volume: $V = N \times \log_2 \eta$
- Difficulty : $D = \frac{\eta_1}{2} \times \frac{N_2}{\eta_2}$
- Effort: $E = D \times V$

The difficulty measure is related to the difficulty of the program to write or understand

The effort measure translates into actual coding time using the following relation,

- Time required to program: $T = \frac{E}{18}$ seconds

Halstead's delivered bugs (B) is an estimate for the number of errors in the implementation.

- Number of delivered bugs : $B = \frac{E^{\frac{2}{3}}}{3000}$ or, more recently, $B = \frac{V}{3000}$ is accepted

Halstead Volume: a composite metric based on the number of (distinct) operators and operands in source code.

Some common-used maintainability metrics

- **Maintainability Index (MI)** 可维护性指数- Calculates an index value between 0 and 100 that represents the relative ease of maintaining the code. A high value means better maintainability. It is calculated based on:
  - Halstead Volume (HV)
  - Cyclomatic Complexity (CC)
  - The average number of lines of code per module (LOC)
  - The percentage of comment lines per module (COM).

$$171-5.2\mathit{ln}(\textsc{hv})-0.23\textsc{cc}-16.2\mathit{ln}(\textsc{loc})+50.0\mathit{sin}\sqrt{2.46 * \textsc{com}}$$

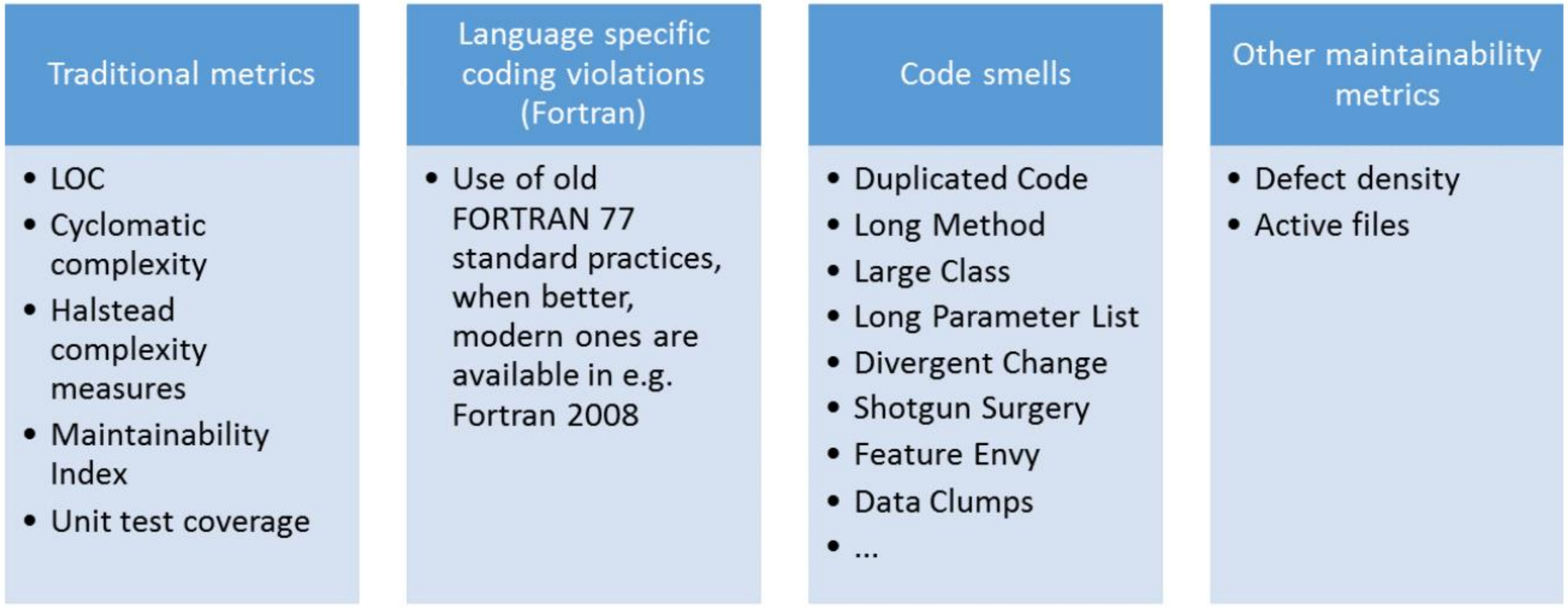
Some common-used maintainability metrics

- **Depth of Inheritance** 继承的层次数 - Indicates the number of class definitions that extend to the root of the class hierarchy. The deeper the hierarchy the more difficult it might be to understand where particular methods and fields are defined or/and redefined.
- **Class Coupling** 类之间的耦合度 - Measures the coupling to unique classes through parameters, local variables, return types, method calls, generic or template instantiations, base classes, interface implementations, fields defined on external types, and attribute decoration.
  - Good software design dictates that types and methods should have high cohesion and low coupling.
  - High coupling indicates a design that is difficult to reuse and maintain because of its many interdependencies on other types.
- **Unit test coverage -** indicates what part of the code base is covered by automated unit tests. (to be studied in Chapter 7)

Many other maintainability metrics

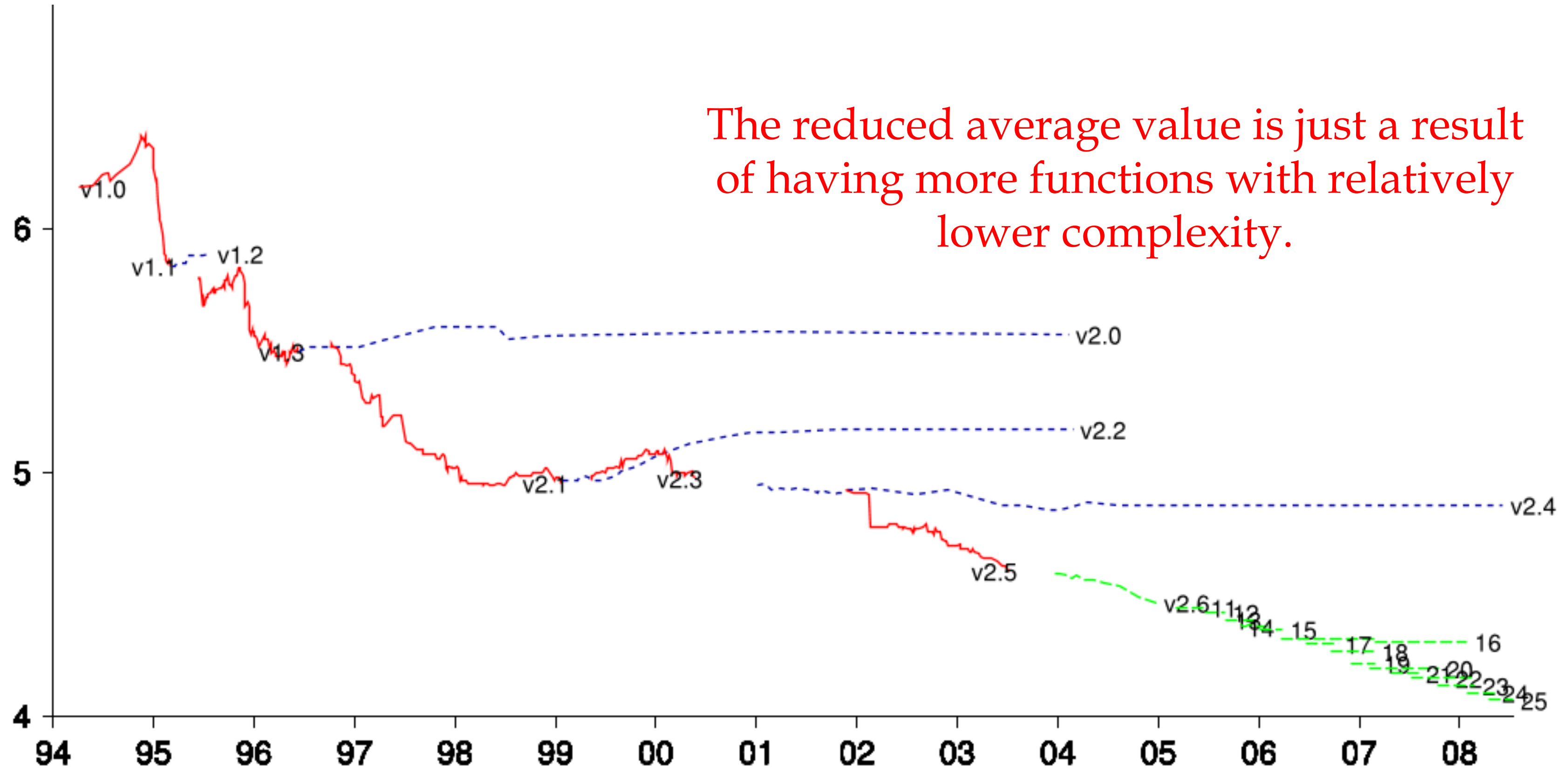
- 请自行查阅资料加以理解

To be discussed in Chapter 9



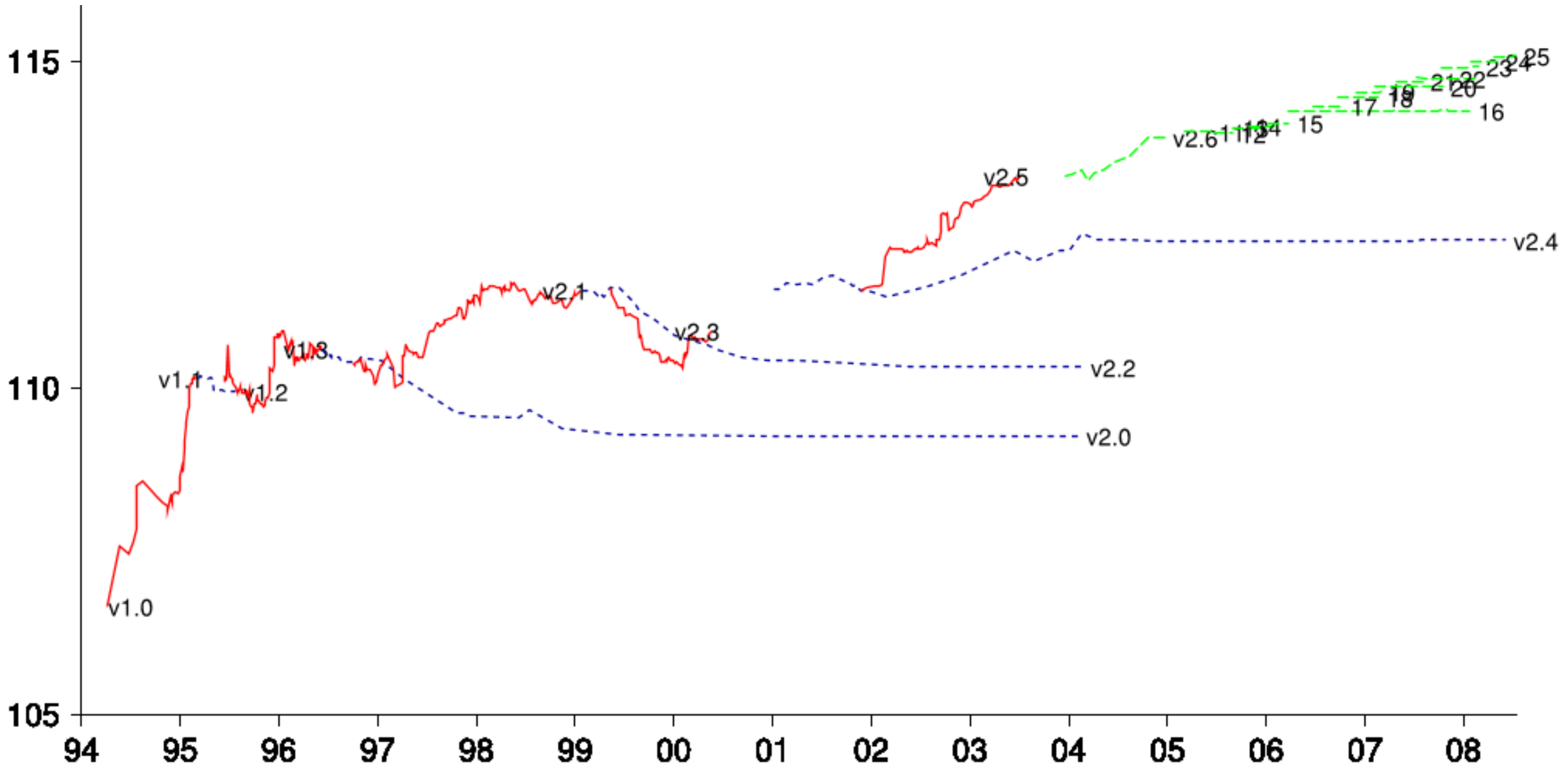
Traditional metrics	Language specific coding violations (Fortran)	Code smells	Other maintainability metrics
• LOC • Cyclomatic complexity • Halstead complexity measures • Maintainability Index • Unit test coverage	• Use of old FORTRAN 77 standard practices, when better, modern ones are available in e.g. Fortran 2008	• Duplicated Code • Long Method • Large Class • Long Parameter List • Divergent Change • Shotgun Surgery • Feature Envy • Data Clumps • …	• Defect density • Active files

Avg. complexity per function in Linux Kernel



The reduced average value is just a result of having more functions with relatively lower complexity.

Maintainability index (MI) of Linux Kernel



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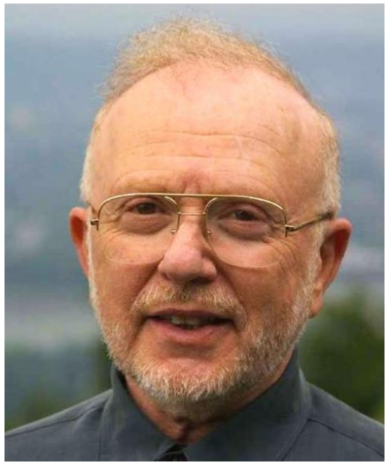
3 Modular Design and Modularity Principles

Modular programming 模块化编程

- **Modular programming is** a design technique that emphasizes separating the functionality of a program into independent, interchangeable modules, such that each contains everything necessary to execute only one aspect of the desired functionality.
- **High-level decomposition of the code of an entire program into pieces in both Structured Programming and OOP.**

Niklaus Wirth (1934-)
Turing Award 1984

Edager Dijkstra (1930-2002)
Turing Award 1972


David L. Parnas (1941-)

Modularity

- **Modularity.** Modularity means dividing up a system into components, or modules, each of which can be designed, implemented, tested, reasoned about, and reused separately from the rest of the system.
  - The opposite of a modular system is a monolithic system – big and with all of its pieces tangled up and dependent on each other.
- A program consisting of a single, very long `main()` function is monolithic – harder to understand, and harder to isolate bugs in.
  - By contrast, a program broken up into small functions and classes is more modular.

Modular programming

- **The goal of design is to partition the system into modules and assign responsibility among the components in a way that:**
  - High cohesion within modules 高内聚
  - Loose coupling between modules 低耦合
- **Modularity reduces the total complexity a programmer has to deal with at any one time assuming:**
  - Functions are assigned to modules in away that groups similar functions together (Separation of concerns) 分离关注点
  - There are small, simple, well-defined interfaces between modules (Information hiding) 信息隐藏
- **The principles of cohesion and coupling are probably the most important design principles for evaluating the maintainability of a design.**

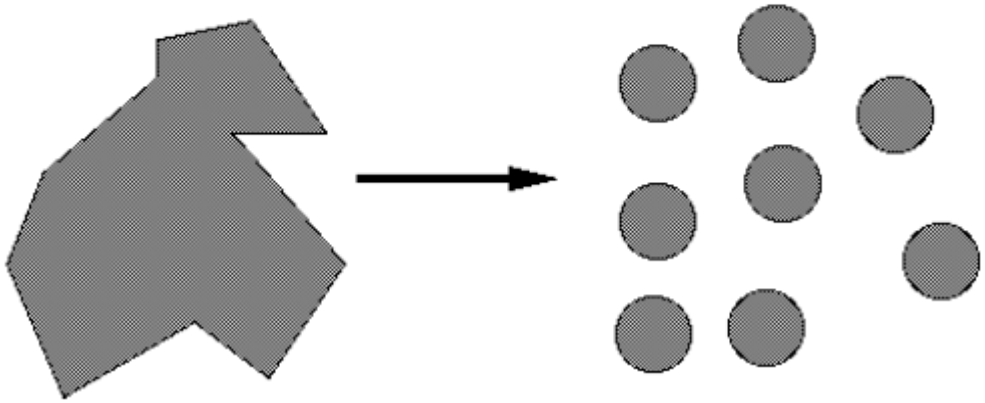
(1) Five Criteria for Evaluating Modularity

Five Criteria for Evaluating Modularity

- **Decomposability (可分解性)**
  - Are larger components decomposed into smaller components?
- **Composability (可组合性)**
  - Are larger components composed from smaller components?
- **Understandability (可理解性)**
  - Are components separately understandable?
- **Continuity (可持续性)**
  - Do small changes to the specification affect a localized and limited number of components?
- **Protection (出现异常之后的保护)**
  - Are the effects of run-time abnormalities confined to a small number of related components?

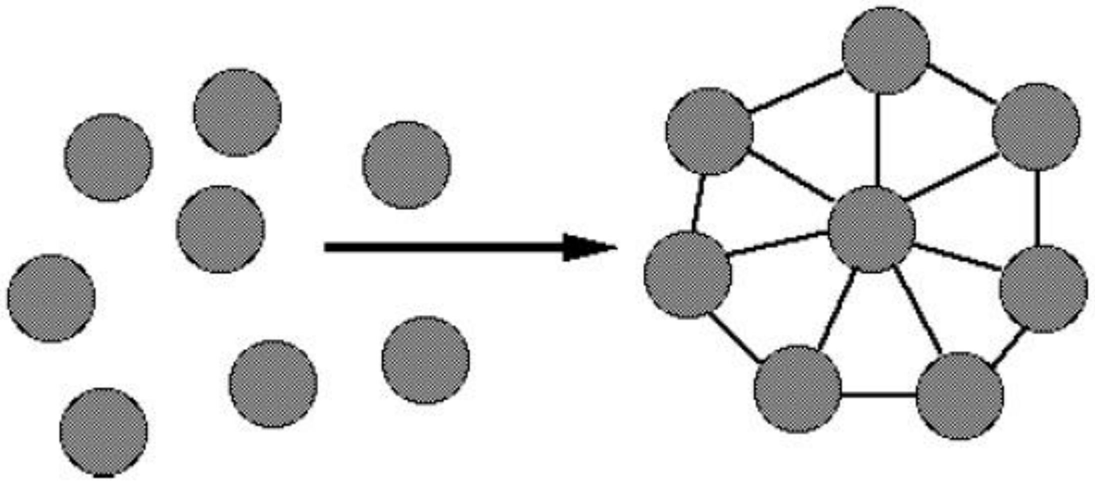
1. Decomposability

- **Decompose problem into smaller sub-problems that can be solved separately (将问题分解为各个可独立解决的子问题)**
  - Goal: keep dependencies explicit and minimal (目标：使模块之间的依赖关系显式化和最小化)
  - Example: top-down structural design



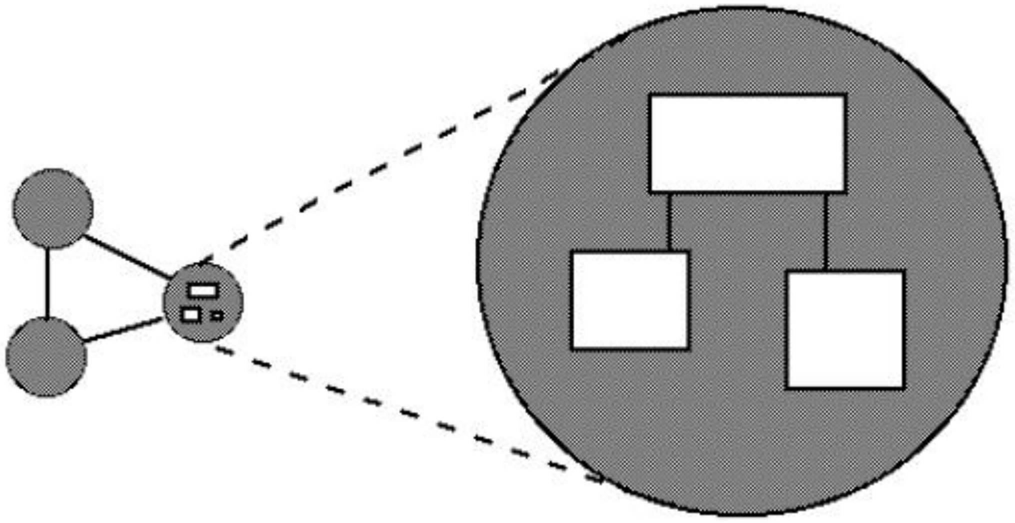
2. Composability

- **Freely combine modules to produce new systems (可容易的将模块组合起来形成新的系统)**
  - Goal: make modules reused in different environments (目标：使模块可在不同的环境下复用)
  - Example: Math libraries; UNIX command & pipes



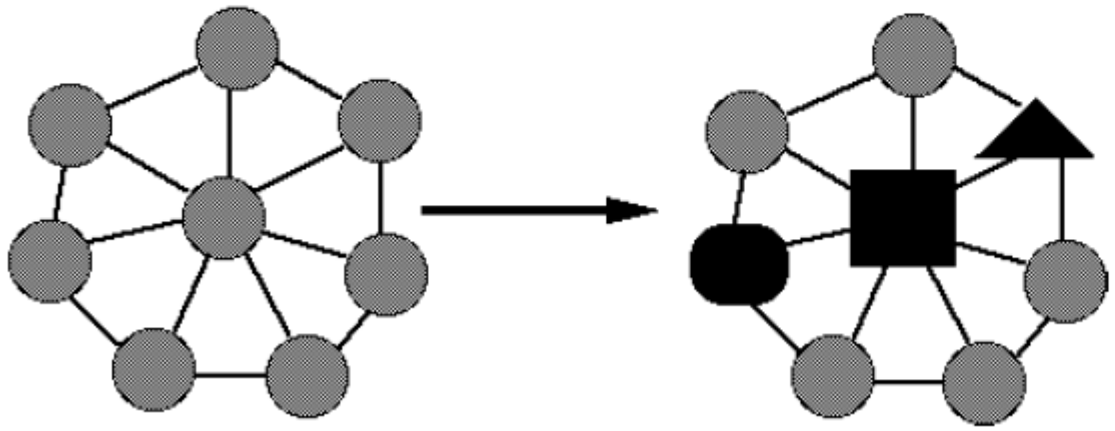
3. Understandability

- **Individual modules understandable by human reader (每个子模块都可被系统设计者容易的理解)**
  - Example: Unix shell such as Program1 | Program2 | Program3
  - Counter-example: Sequential Dependencies (A →B → C)



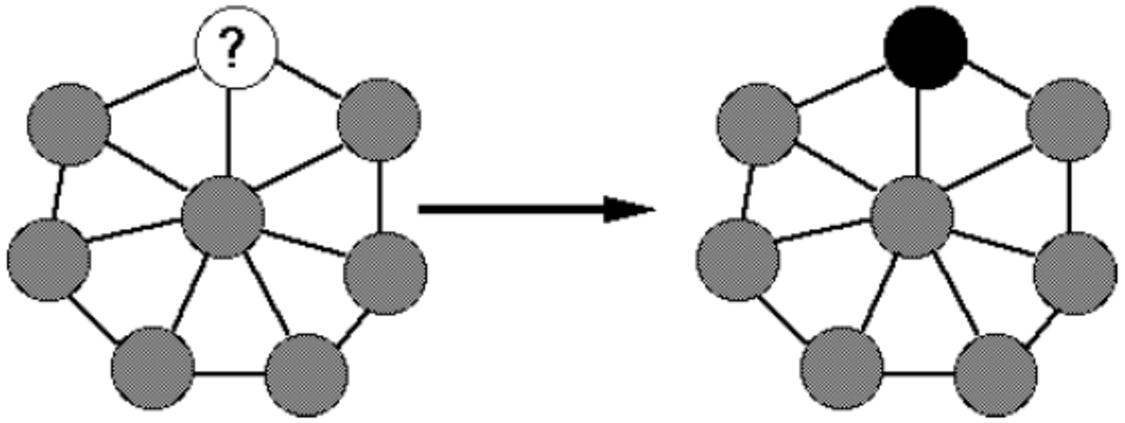
4. Continuity

- **Small change in specification results in:**
  - changes in only a few modules and does not affect the architecture (小的变化将只影响一小部分模块，而不会影响整个体系结构)
  - Example: Symbolic Constants (符号型变量)
    - const String PRODUCT_CODE = “PBS001291A”
  - Example: Principle of Uniform Access



5. Protection

- **Effects of an abnormal run-time condition is confined to a few modules (运行时的不正常将局限于小范围模块内)**
  - Example: Validating input at source



(2) Five Rules of Modularity Design

Five Rules of Modularity Design

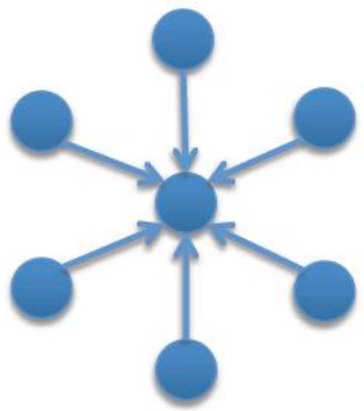
- **Direct Mapping (直接映射)**
- **Few Interfaces (尽可能少的接口)**
- **Small Interfaces (尽可能小的接口)**
- **Explicit Interfaces (显式接口)**
- **Information Hiding (信息隐藏)**

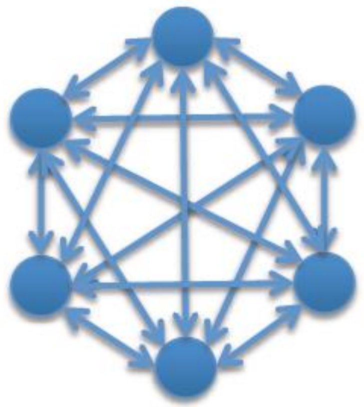
1. Direct Mapping

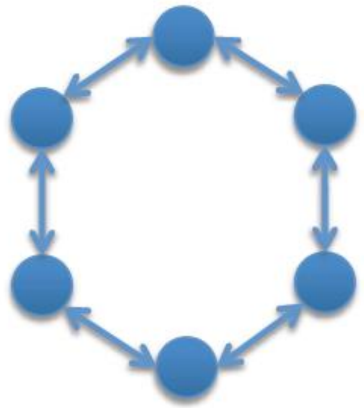
- **Direct mapping: keep the structure of the solution compatible with the structure of the modeled problem domain (直接映射：模块的结构与现实世界中问题领域的结构保持一致)**
- **Impact on (对以下评价标准产生影响):**
  - Continuity (持续性)
    - Easier to assess and limit the impact of change
  - Decomposability (可分解性)
    - Decomposition in the problem domain model as a good starting point for the decomposition of the software

2. Few Interfaces

- **Every module should communicate with as few others as possible (模块应尽可能少的与其他模块通讯)**
  - 通讯路径的数目: n-1, n(n-1)/ 2, n-1
  - Affects Continuity, Protection, Understandability and Composability (对以下评价标准产生影响：可持续性、保护性、可理解性、可组合性)







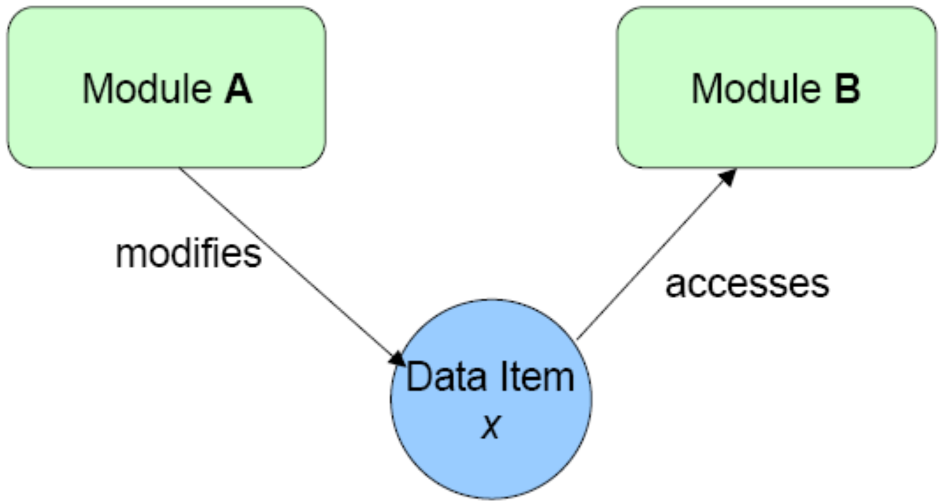
3. Small Interfaces

- **If two modules communicate, they should exchange as little information as possible (如果两个模块通讯，那么它们应交换尽可能少的信息)**
  - limited “bandwidth” of communication (限制模块之间通讯的“带宽”)
  - Continuity and Protection (对“可持续性”和“保护性”产生影响)

4. Explicit Interface

- **Whenever two modules A and B communicate, this must be obvious from the text of A or B or both (当A与B通讯时，应明显的发生在A与B的接口之间)**
  - Decomposability, Composability, Continuity, Understandability (受影响的评价标准：可分解性、可组合性、可持续性、 可理解性)

反例：



A short summary

- **(2) Few Interfaces:** *"Don't talk to many!"*

  尽可能少的接口： "不要对太多人讲话..."

- **(3) Small Interfaces:** *"Don't talk a lot!"*

  尽可能小的接口： "不要讲太多..."

- **(4) Explicit Interfaces:** *"Talk loud and in public! Don't whisper!"*

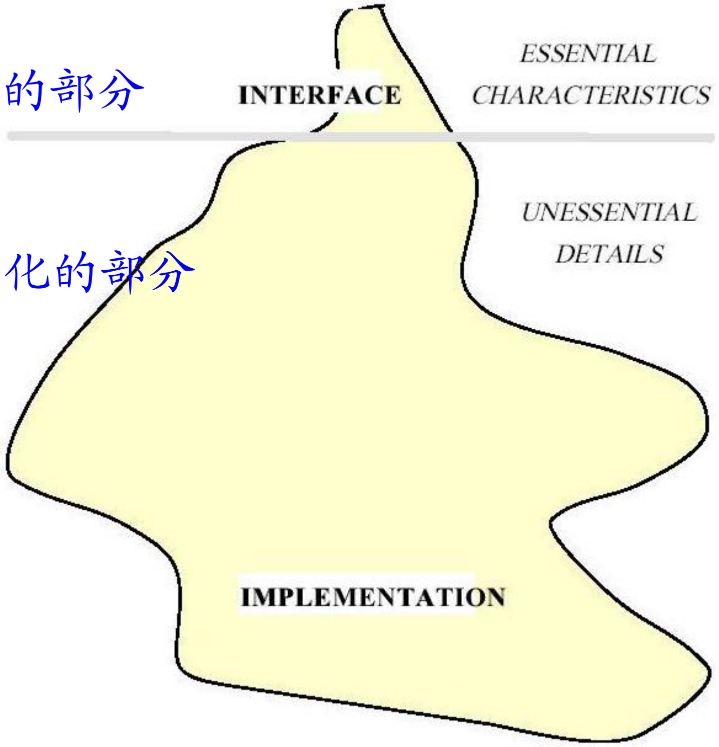
  显式接口： "公开的大声讲话...不要私下嘀咕..."

5. Information Hiding

- **Motivation: design decisions that are subject to change should be hidden behind abstract interfaces (经常可能发生变化的设计决策应尽可能隐藏在抽象接口后面)**
  - Rep/RI/AF
  - Interface/Abstract Class/Class

较少发生变化的部分

需要经常发生变化的部分



- **The designer of every module must select a subset of the module's properties as the official information about the module, to be made available to client modules.**

Example 1: Comparing the two designs

Design 1:

```
class PersistentData {

    public ResultSet read(String sql);
    // write returns the number of rows effected
    public int write(String sql);

}


PersistentData db = new PersistentData();
db.write( “UPDATE Employees SET Dependents = 2
          WHERE EmployeeID = 47” );
```

Example 1

Design 2:

```
class EmployeeGateway {

    public static EmployeeGateway find(int ID);
    public void setName(string name);
    public string getName();
    public void setDependents(int dependents);
    public int getDependents();
    public int insert();
    public void update();
    public void delete();

}


EmployeeGateway e = EmployeeGateway.find(47);
e.setDependents(2);
e.update();
```

Example 2

```
class Course {
    private Set students;
    public Set getStudents() {
        return students;
    }
    public void setStudents(Set s) {students = s;}
}

-------------------------------------------------------------------------

class Course {
    private Set students;
    public Set getStudents() {
        return Collections.unmodifiableSet(students);
    }
    public void addStudent(Student student) {
        students.add(student);
    }
    public void removeStudent(Student student) {
        students.remove(student);
    }
}
```

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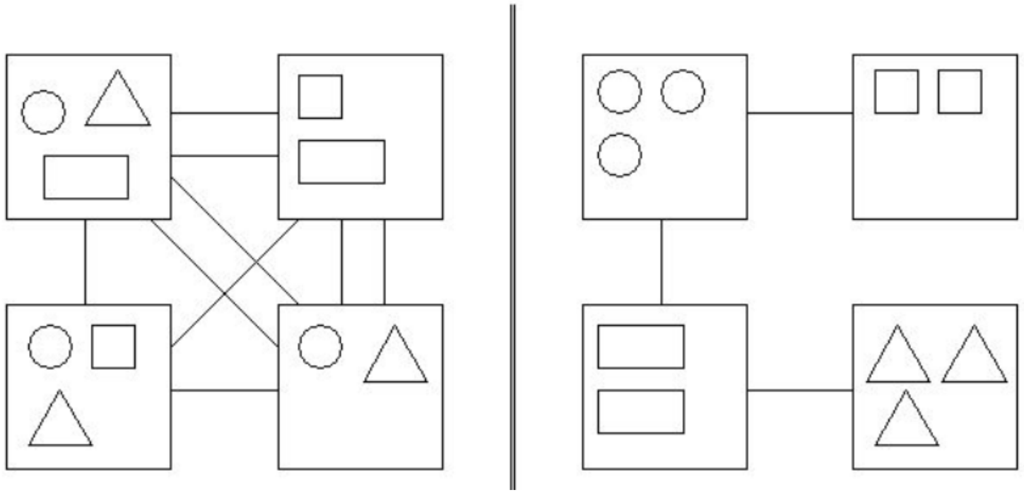
(3) Coupling and Cohesion

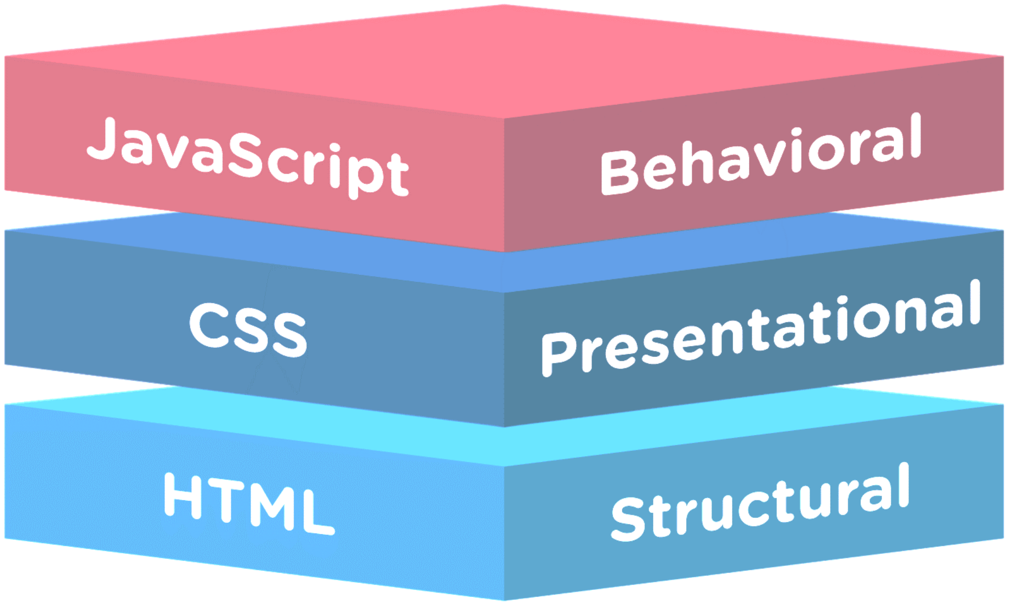
Coupling

- **Coupling is the measure of dependency between modules. A dependency exists between two modules if a change in one could require a change in the other.**
- **The degree of coupling between modules is determined by:**
  - The number of interfaces between modules (quantity), and
  - Complexity of each interface (determined by the type of communication) (quality)



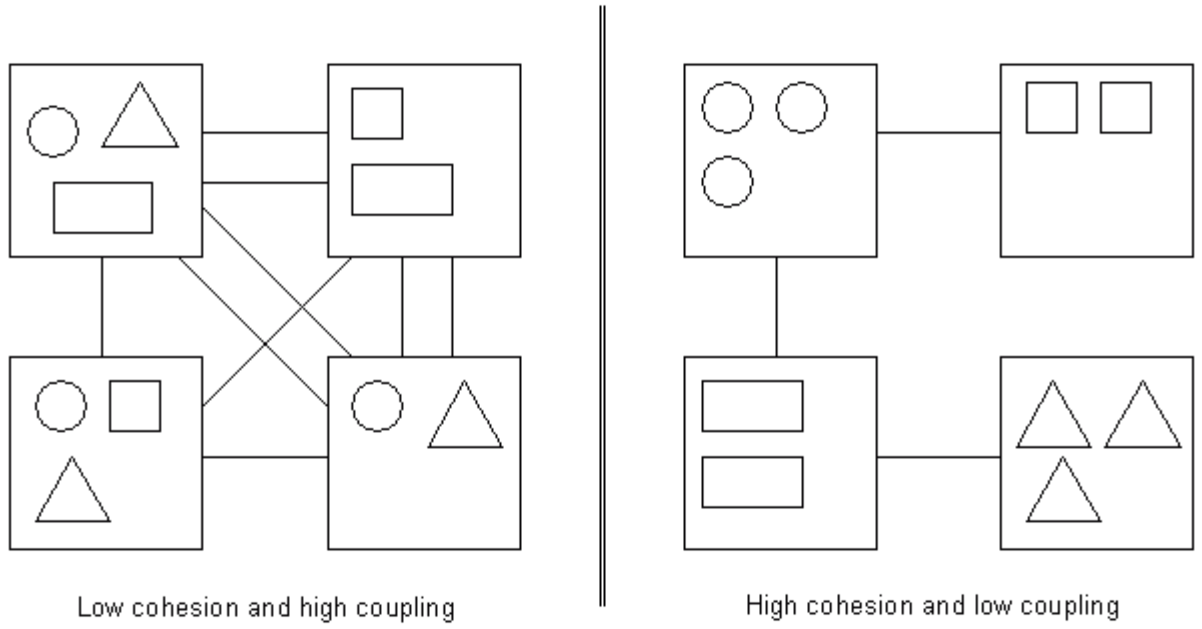
Coupling between HTML, CSS and JavaScript

- **A well-designed web app modularizes around:**
  - HTML files which specify data and semantics
  - CSS rules which specify the look and formatting of HTML data
  - JavaScript which defines behavior/interactivity of page
- **Assume you have the following HTML and CSS definitions.**



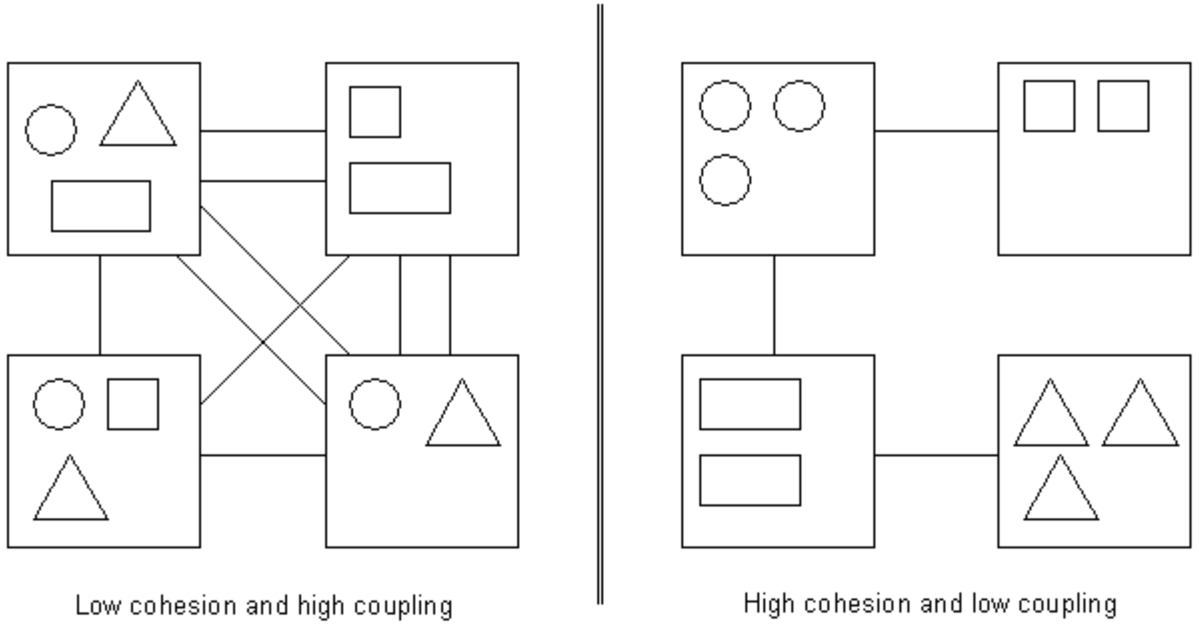
Cohesion

- **Cohesion is a measure of how strongly related the functions or responsibilities of a module are.**
- **A module has high cohesion if all of its elements are working towards the same goal.**

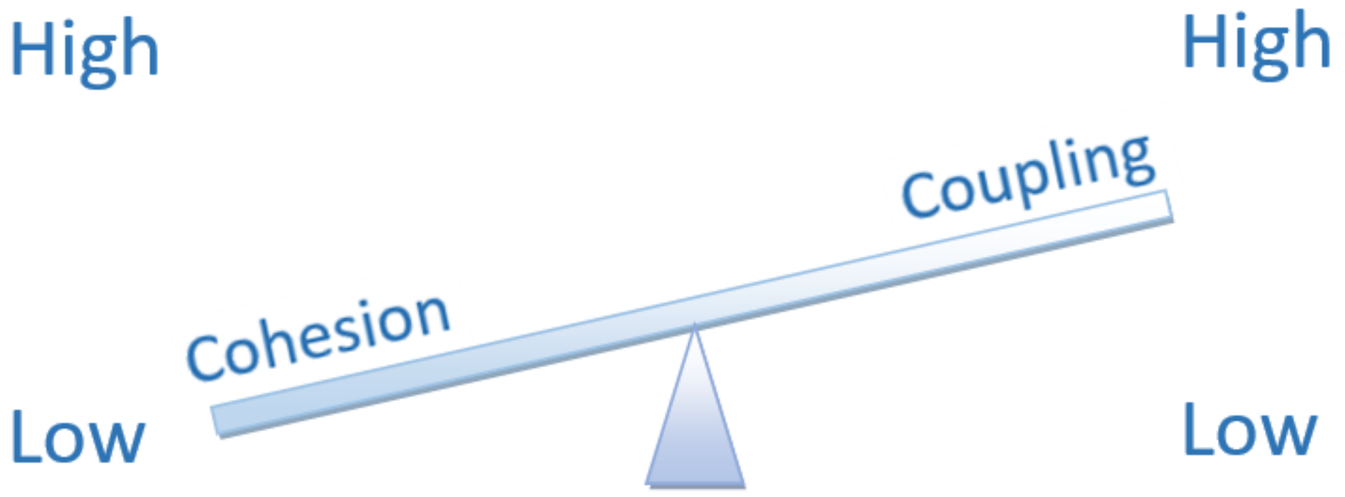

Low cohesion and high coupling
High cohesion and low coupling

Cohesion and Coupling

- **The best designs have high cohesion (also called strong cohesion) within a module and low coupling (also called weak coupling) between modules.**


Low cohesion and high coupling
High cohesion and low coupling

Coupling and Cohesion are with trade-off



- **When Coupling is high, cohesion tends to be low and vise versa.**

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4 OO Design Principles: SOLID

SOLID: 5 classes design principles

(SRP) The Single Responsibility Principle	单一责任原则
(OCP) The Open-Closed Principle	开放–封闭原则
(LSP) The Liskov Substitution Principle	Liskov替换原则
(DIP) The Dependency Inversion Principle	依赖转置原则
(ISP) The Interface Segregation Principle	接口聚合原则

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(1) Single Responsibility Principle (SRP)

Single Responsibility Principle

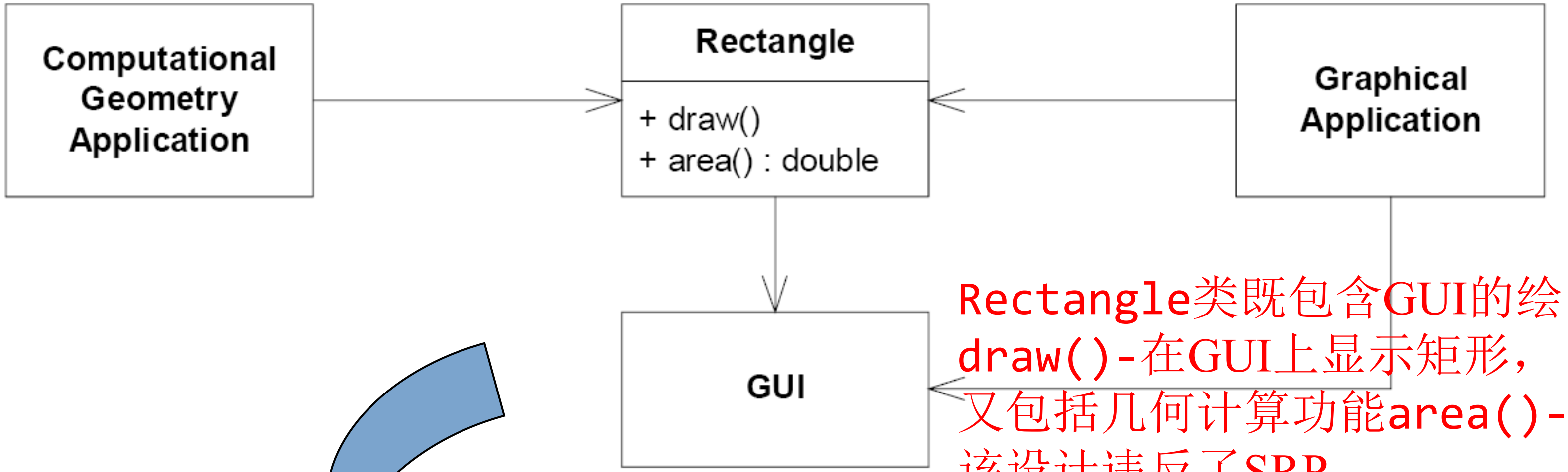
- **“There should never be more than one reason for a class to change”, i.e., a class should concentrate on doing one thing and one thing only.**

Just because you can, doesn’t mean you should

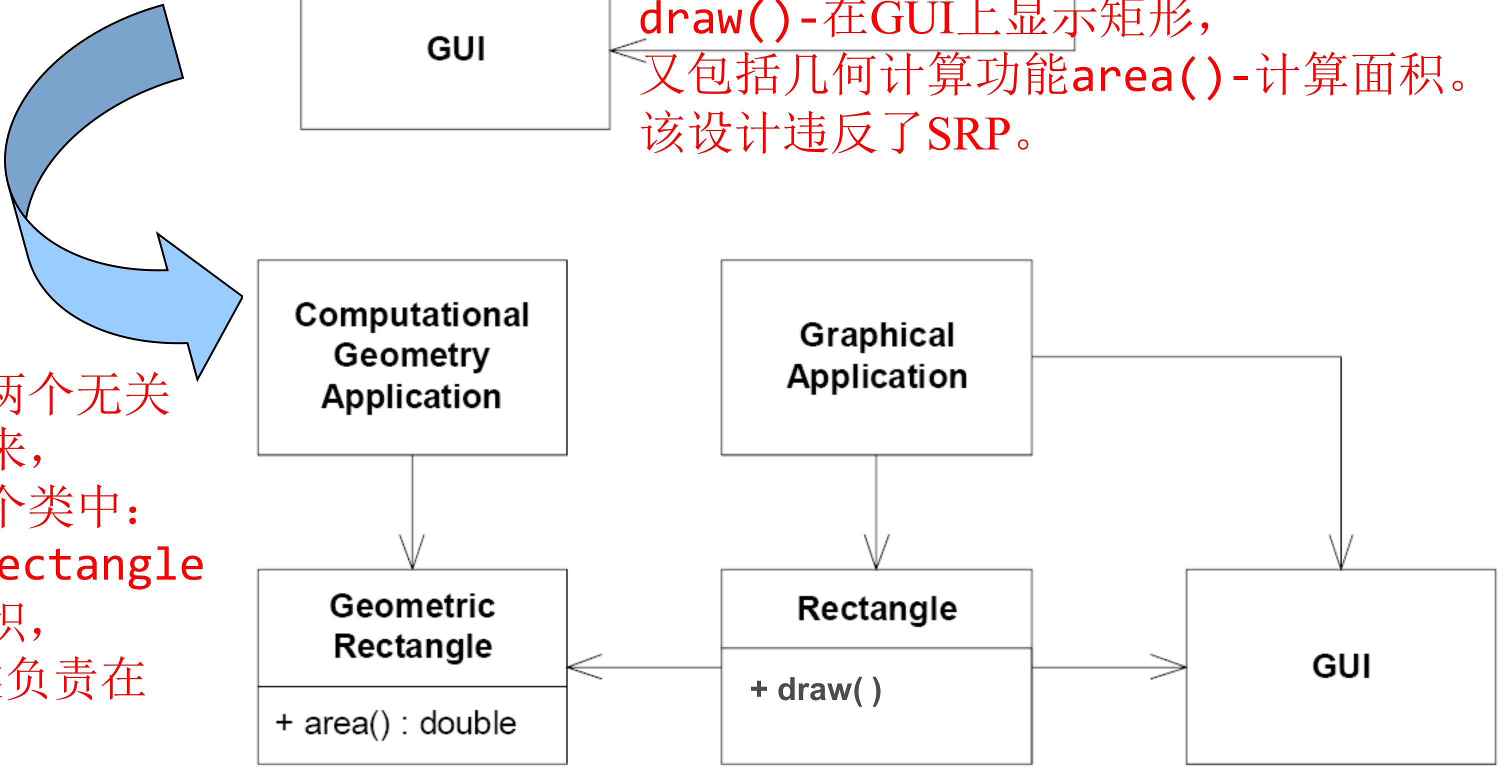
(SRP) The Single Responsibility Principle

- **Responsibility: “a reason for change.” (责任：变化的原因)**
- **SRP:**
  - There should never be more than one reason for a class to change. (不应有多于1个的原因使得一个类发生变化)
  - One class, one responsibility. (一个类，一个责任)
- 如果一个类包含了多个责任，那么将引起不良后果：
  - 引入额外的包，占据资源
  - 导致频繁的重新配置、部署等
- **The SRP is one of the simplest of the principle, and one of the hardest to get right. (最简单的原则，却是最难做好的原则)**

SRP的一个反例



Rectangle类既包含GUI的绘图功能draw()-在GUI上显示矩形，又包括几何计算功能area()-计算面积。该设计违反了SRP。



通过分解，将两个无关的责任分离开来，分别放置在两个类中：

- Geometric Rectangle类负责计算面积，
- Rectangle类负责在GUI上绘图。

Single Responsibility Principle

- **Two resposibilities**
  - Connection Management
  - Data Communication

```
interface Modem {
 public void dial(String pno);
 public void hangup();

 public void send(char c);
 public char recv();
}
```

```
interface DataChannel {
 public void send(char c);
 public char recv();
}
```

```
interface Connection {
 public void dial(String phn);
 public char hangup();
}
```

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(2) Open/Closed Principle (OCP)

(OCP) The Open-Closed Principle

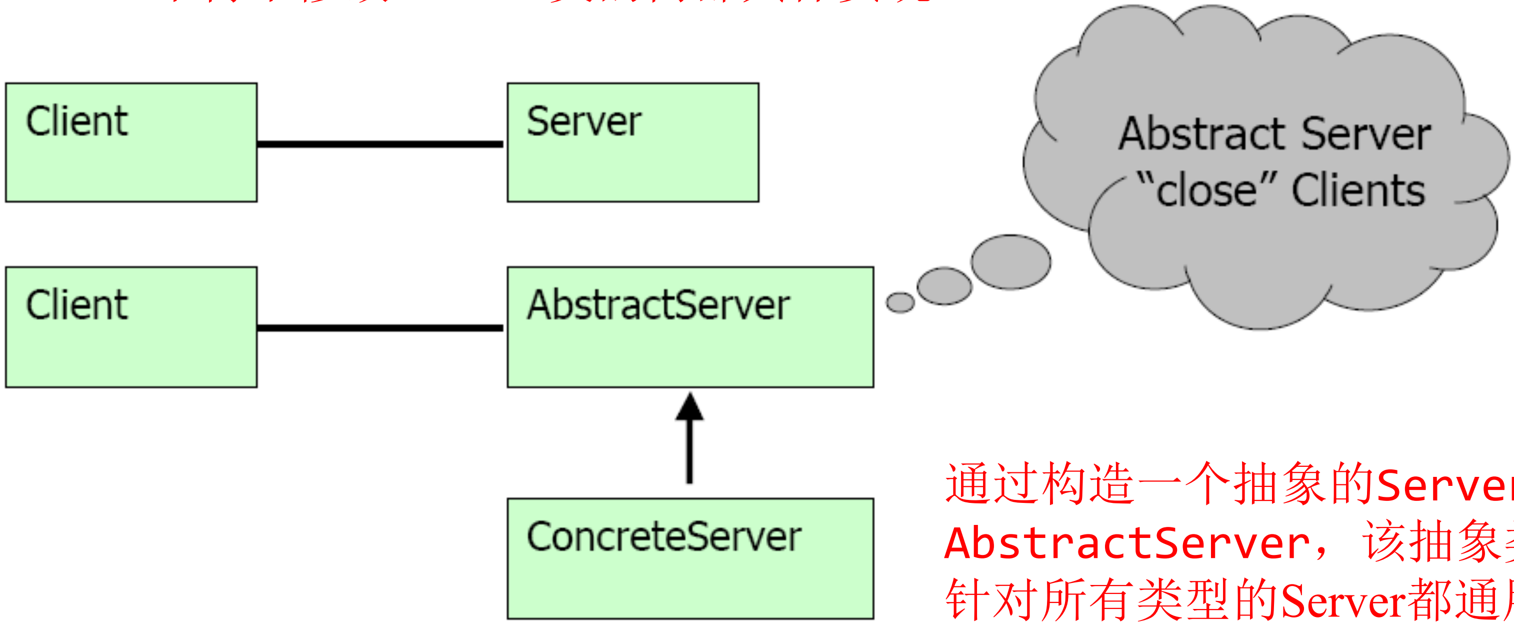
- **Classes should be open for extension (对扩展性的开放)**
  - This means that the behavior of the module can be extended. That we can make the module behave in new and different ways as the requirements of the application change, or to meet the needs of new applications. (模块的行为应是可扩展的，从而该模块可表现出新的行为以满足需求的变化)
- **But closed for modification. (对修改的封闭)**
  - The source code of such a module is inviolate. No one is allowed to make source code changes to it. (但模块自身的代码是不应被修改的)
  - The normal way to extend the behavior of a module is to make changes to that module. (扩展模块行为的一般途径是修改模块的内部实现)
  - A module that cannot be changed is normally thought to have a fixed behavior. (如果一个模块不能被修改，那么它通常被认为是具有固定的行为)

Open Closed Principle

- **Key: abstraction (关键的解决方案：抽象技术)**
- **"Software entities (classes, modules, functions, etc.) should be open for extension, but closed for modification“, i.e., change a class' behavior using inheritance and composition**

OCP的一个反例

如果有多种类型的Server，那么针对每一种新出现的Server，不得不修改Server类的内部具体实现。



通过构造一个抽象的Server类：AbstractServer，该抽象类中包含针对所有类型的Server都通用的代码，从而实现了对修改的封闭；
当出现新的Server类型时，只需从该抽象类中派生出具体的子类ConcreteServer即可，从而支持了对扩展的开放。

Open Closed Principle

```
// Open-Close Principle - Bad example
 class GraphicEditor {

 public void drawShape(Shape s) {
    if (s.m_type==1)
        drawRectangle(s);
    else if (s.m_type==2)
        drawCircle(s);
    }
    public void drawCircle(Circle r)
        {....}
    public void drawRectangle(Rectangle r)
        {....}
 }
```

```
class Shape {
    int m_type;
 }

 class Rectangle extends Shape {
    Rectangle() {
        super.m_type=1;
    }
 }

 class Circle extends Shape {
    Circle() {
        super.m_type=2;
    }
 }
```

Open Closed Principle – a Few Problems….

- **Impossible to add a new** `Shape` **without modifying** `GraphEditor`
- **Important to understand** `GraphEditor` **to add a new** `Shape`
- **Tight coupling between** `GraphEditor` **and** `Shape`
- **Difficult to test a specific** `Shape` **without involving** `GraphEditor`
- `If-Else-/Case` **should be avoided**

Open Closed Principle - Improved

```
// Open-Close Principle - Good example

class GraphicEditor {
   public void drawShape(Shape s) {
     s.draw();
   }
}

class Shape {
   abstract void draw();
}

class Rectangle extends Shape {
   public void draw() {
   // draw the rectangle
   }
}
```

OCP indicates Single Choice

- **Whenever a software system must support a set of alternatives, one and only one module in the system should know their exhaustive list.**

- **Editor: set of commands (insert, delete etc.)**
- **Graphics system: set of figure types (rectangle, circle etc.)**
- **Compiler: set of language constructs (instruction, loop, expression etc.)**

(3) Liskov Substitution Principle (LSP)

(LSP) The Liskov Substitution Principle

- **"Functions that use pointers or references to base classes must be able to use objects of derived classes without knowing it“, i.e., subclasses should behave nicely when used in place of their base class**

- **LSP: Subtypes must be substitutable for their base types. (子类型必须能够替换其基类型)**

- **Derived Classes must be usable through the base class interface without the need for the client to know the difference. (派生类必须能够通过其基类的接口使用，客户端无需了解二者之间的差异)**

→ Already discussed in Section 5-2 Reusability

(4) Interface Segregation Principle (ISP)

Interface Segregation Principle

- **"Clients should not be forced to depend upon interfaces that they do not use“, i.e., keep interfaces small.**

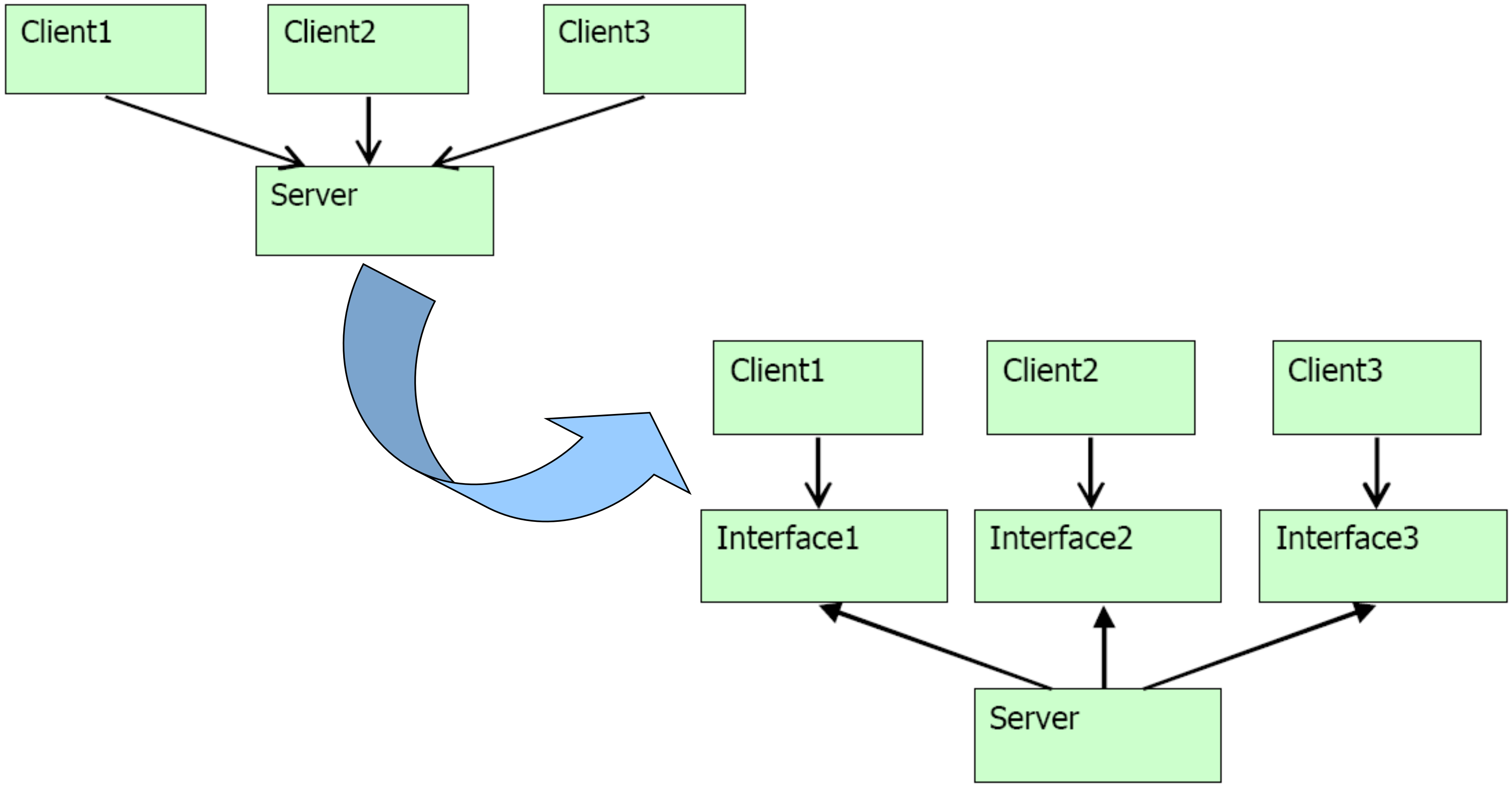
- **Don’t force classes so implement methods they can’t (Swing/Java)**
- **Don’t pollute interfaces with a lot of methods**
- **Avoid ’fat’ interfaces**

(ISP) The Interface Segregation

- **Clients should not be forced to depend upon methods that they do not use. (客户端不应依赖于它们不需要的方法)**
- **Interfaces belong to clients, not to hierarchies.**

- **This principle deals with the disadvantages of "fat" interfaces. ("胖"接口具有很多缺点)**
- **Classes that have "fat" interfaces are classes whose interfaces are not cohesive. (不够聚合)**
  - The interfaces of the class can be broken up into groups of member functions. (胖接口可分解为多个小的接口)
  - Each group serves a different set of clients (不同的接口向不同的客户端提供服务).
  - Thus some clients use one group of member functions, and other clients use the other groups. (客户端只访问自己所需要的端口)

(ISP) The Interface Segregation Principle



Interface Segregation Principle

```
//bad example (polluted interface)
interface Worker {
    void work();
    void eat();
}
ManWorker implements Worker {
    void work() {…};
    void eat() {…};
}
RobotWorker implements Worker {
    void work() {…};
    void eat() {//Not Appliciable
                 for a RobotWorker};
}
```

Solution: split into two

```
interface Workable {
   public void work();
}

interface Feedable{
   public void eat();
}
```

(5) Dependency Inversion Principle (DIP)

(DIP) The Dependency Inversion Principle

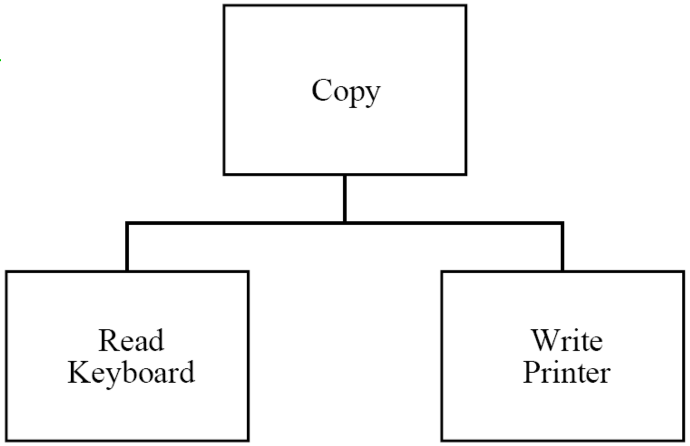
- **High level modules should not depend upon low level modules. Both should depend upon abstractions.**
  - Abstractions should not depend upon details (抽象的模块不应依赖于具体的模块)
  - Details should depend upon abstractions (具体应依赖于抽象)

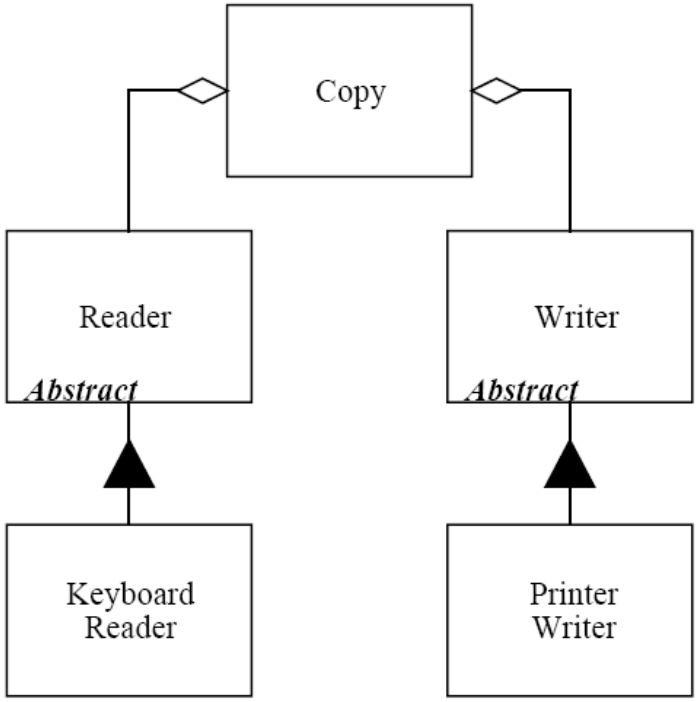
- **Lots of interfaces and abstractions should be used!**

Example: the “Copy” program

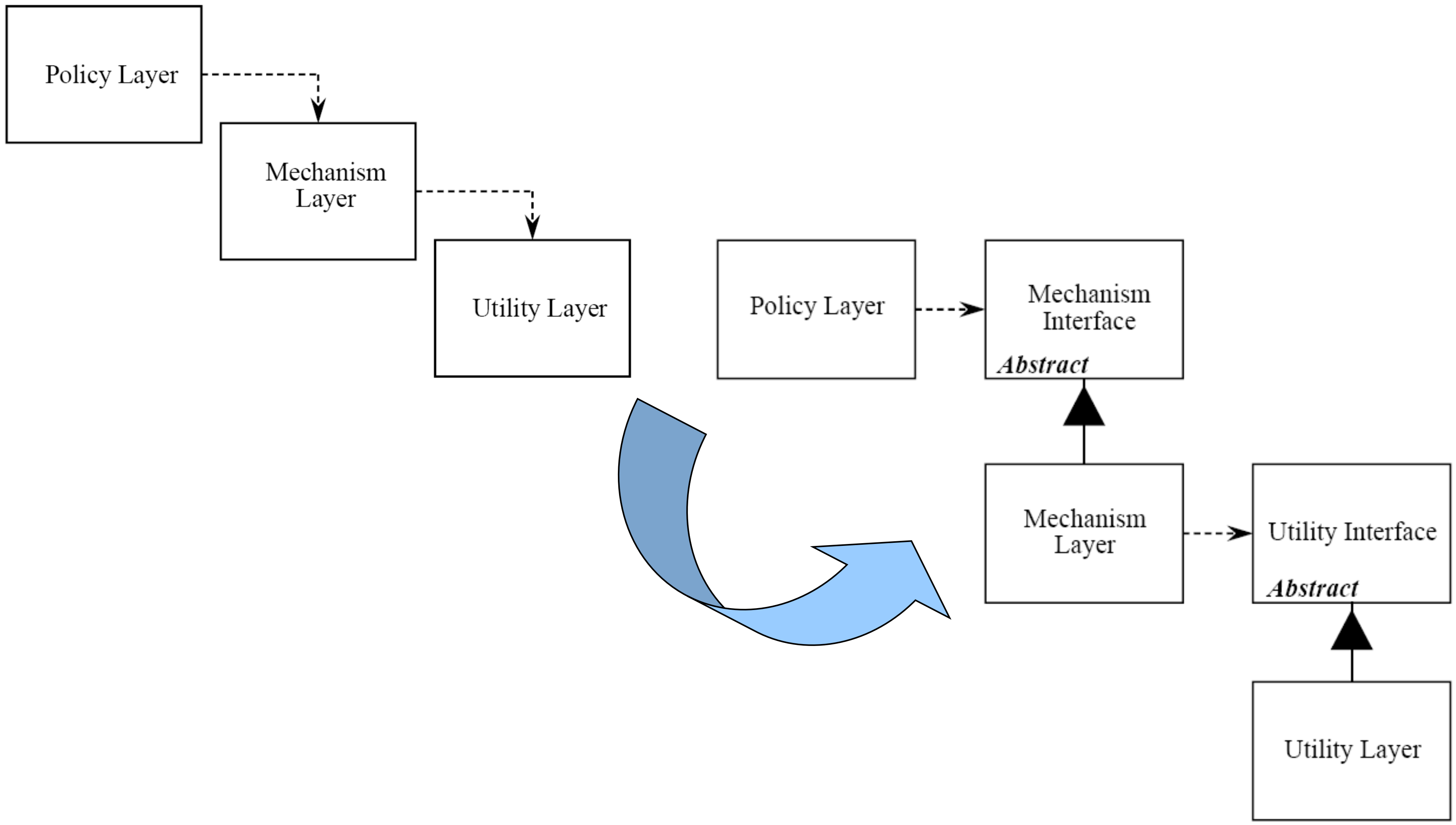
```
void Copy(OutputStream dev) {
   int c;
   while ((c = ReadKeyboard()) != EOF)
        if (dev == printer)
           writeToPrinter(c);
        else
           writeToDisk(c);
}
```

```
interface Reader {
  public int read();
}
interface Writer {
  public int write(c);
}
class Copy {
  void Copy(Reader r, Writer w) {
     int c;
     while (c=r.read() != EOF)
        w.write(c);
  }
}
```





DIP: another example



Dependency Inversion Principle

```
//DIP - bad example
public class EmployeeService {
        private EmployeeFinder emFinder //concrete class, not abstract.
        //Can access a SQL DB for instance
        public Employee findEmployee(…) {
                emFinder.findEmployee(…)
        }
}
//DIP - fixed
public class EmployeeService {
        private IEmployeeFinder emFinder
        //depends on an abstraction, no an implementation

        public Employee findEmployee(…) {
           emFinder.findEmployee(…)
        }
}
```

- **Now its possible to change the finder to be a** `XmEmployeeFinder`, `DBEmployeeFinder`, `FlatFileEmployeeFinder`, `MockEmployeeFinder`**….**

Why DIP?

- **Advantages:**
  - Formalize class contracts.
  - You an define the services of a routine in terms of pre- and post-conditions. This makes it very clear what to expect.

- **Try Design for Testing**
  - Create a test-friendly design
  - A test-friendly module is likely to exhibit other important design characteristics.
  - Example: you would avoid circular dependencies. Business logic will be better isolated from UI code if you have to test it separately from the UI

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5 OO Design Principles: GRASP

What's GRASP patterns

- **General Responsibility Assignment Software Patterns (principles)**, abbreviated **GRASP**, consist of guidelines for assigning responsibility to classes and objects in OOP.

- **The GRASP patterns are a learning aid to help one understand essential object design, and apply design reasoning in a methodical, rational, explainable way.**

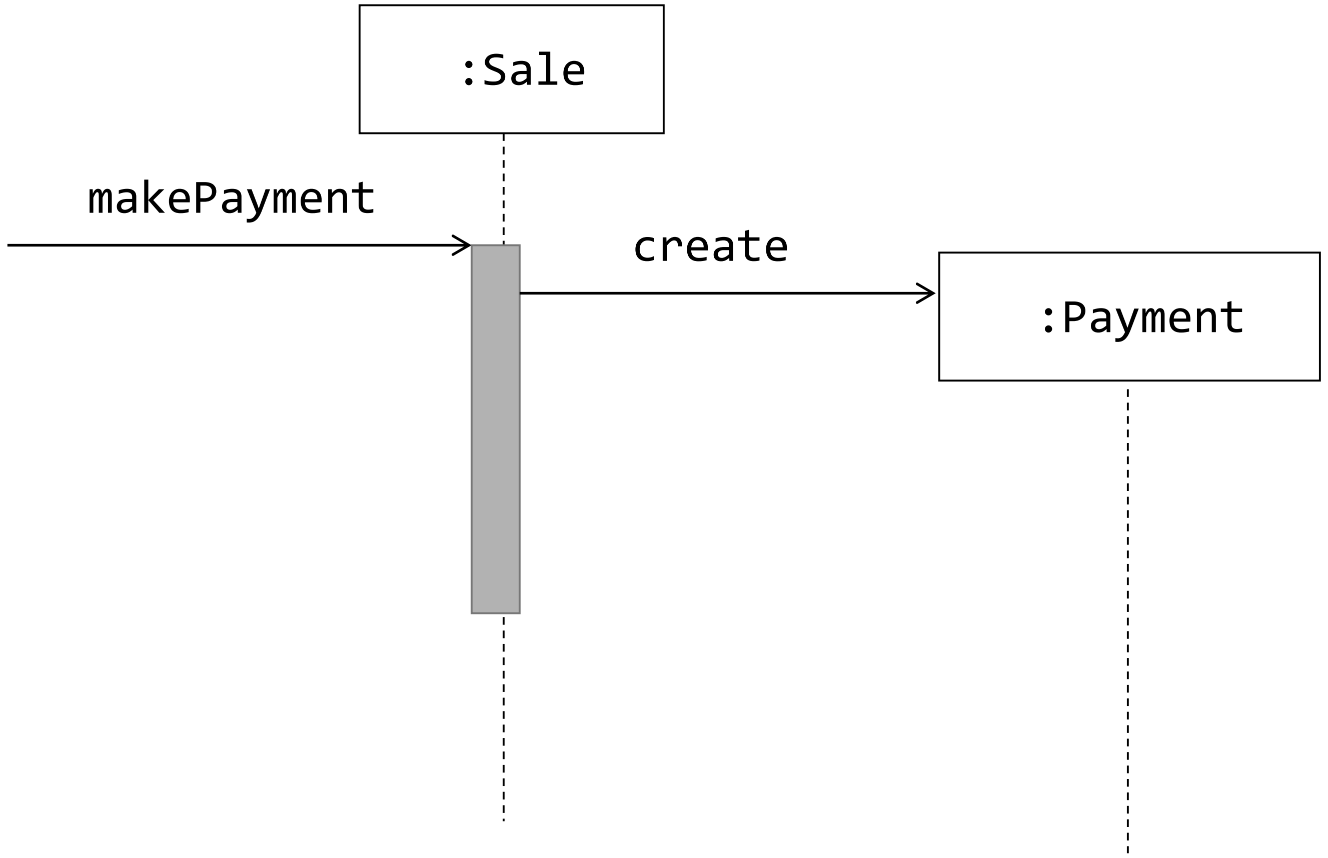
- **This approach to understanding and using design principles is based on patterns of assigning responsibilities to classes.**

GRASP是关于如何为“类”和“对象”指派“职责”的一系列原则

What's responsibility

- **Responsibility of an object: related to the obligations of an object**
- **Knowing:**
  - Knowing about private encapsulated data
  - Knowing about related objects
  - Knowing about things it can derive or calculate
- **Doing:**
  - Doing something itself, such as creating an object or doing a calculation
  - Initiating action in other objects
  - Controlling and coordinating activities in other objects.

Responsibilities and methods



Responsibilities are implemented using methods:
`makePayment` implies `Sale` object has a responsibility to create a `Payment` object

What is GRASP composed of?

- **Controller**
- **Information expert**
- **Creator**
- **Low coupling**
- **High cohesion**
- **Indirection**
- **Polymorphism**
- **Protected variations**
- **Pure fabrication**

Learn GRASP by yourself
from
CMU course
and
Wikipedia

Summary

Summary

- **Software Maintenance and Evolution**
- **Metrics of Maintainability**
- **Modular Design and Modularity Principles**
- **OO Design Principles: SOLID**
- **OO Design Principles: GRASP**

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The end

April 7, 2018