

INFORMATION HIDING

Yuqun Zhang

A Programmer's Approach to Software Engineering

- Skip requirements engineering and design phases... just start coding
- Why?
 - Design is a waste of time.
 - We need to show something to the customer really quick.
 - I'm graded by the number of lines of code I write per unit time
 - I think the schedule is too tight

But...

***The longer you postpone coding, the sooner you will
be finished.***

Design Overview

- Design is a trial-and-error process
- The process is not the same as the outcome of that process
- There is an interaction between requirements engineering and design

Software Design Caveats

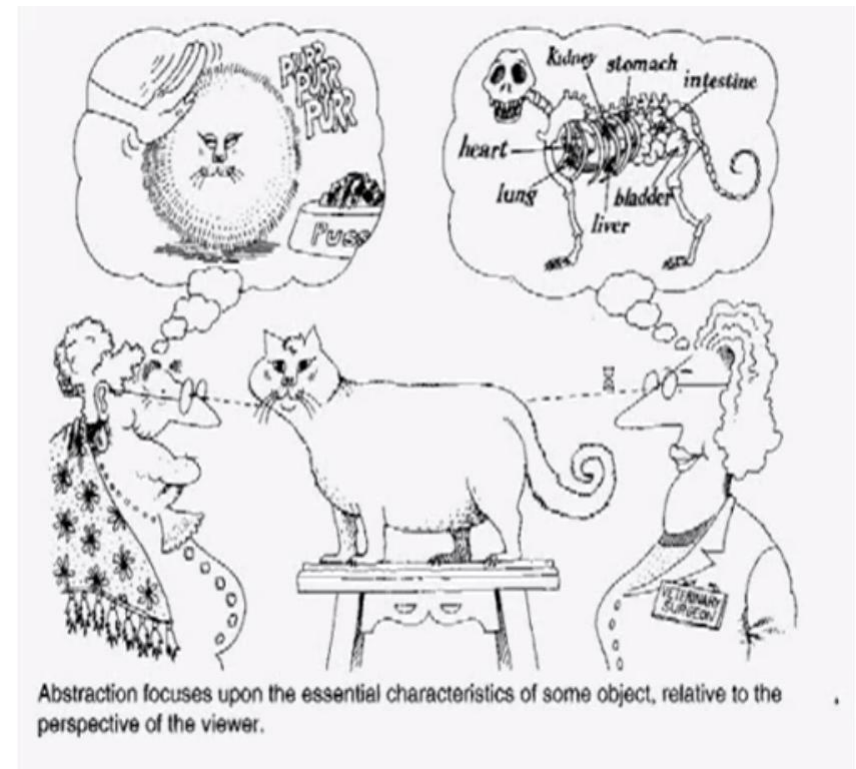
- There is no definite formulation
- There is no stopping rule
- Solutions are not simply true or false

Software Design Principles

- Abstraction
- Modularity, coupling, and cohesion
- Information hiding
- Limited complexity
- Hierarchical structure

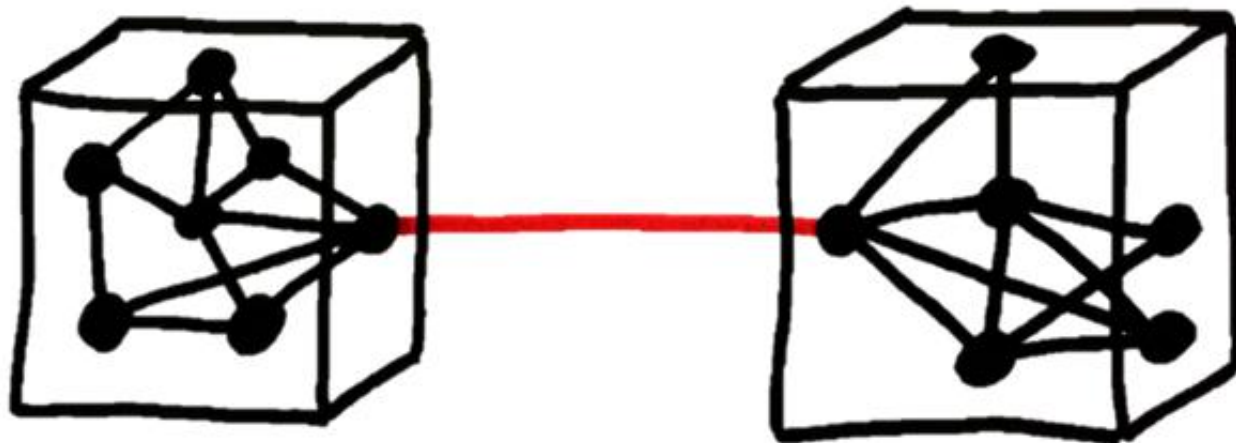
Abstraction

- Procedural abstraction
 - A natural consequence of stepwise refinement
 - Name of procedure denotes the sequence of actions
- Data abstraction
 - Goal is to find a hierarchy in the data (e.g., the range from general purpose data structures to application-oriented data structures)



Modularity

- Modularity identifies structural criteria that tell something about individual modules and their interconnections
- Key concepts: cohesion and coupling
 - Cohesion: the glue that keeps a module together
 - Coupling: the strength of the connections between modules



Information Hiding

- Information hiding is a principle for breaking a program into modules

*Design decisions that are likely to change independently should be **secrets** of separate modules*

*The only assumptions that should appear in the **interfaces** between modules are those that are considered unlikely to change*

Information Hiding

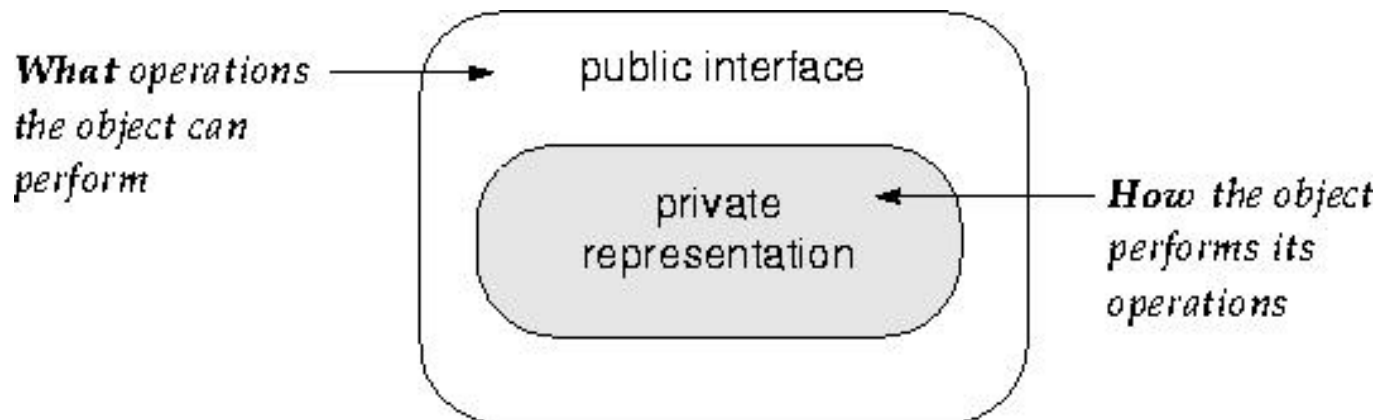
- Each module has a secret
- The design involves a series of decisions
 - For each decision, consider what other modules need to know and what others can be kept in the dark
- Information hiding is strongly related to
 - Abstraction: if you hide something, the user may abstract from that fact
 - Coupling: the secret decreases coupling between a module and the environment
 - Cohesion: the secret is what binds the parts of the module together

Real-life Examples

- Your brain (your name and your experiences)
- An Email server (Account information)

Motivation for Information Hiding

- A fundamental cost in software engineering is accommodating change
 - Changes that require modifications to more modules are more costly than changes that are isolated to single modules
- The goal:
 - Anticipate likely changes
 - Define interfaces that capture the stable aspects and implementations that capture the changeable aspects



A Simple Example

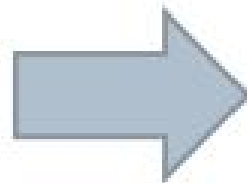
```
double sqrt (int)
```

- Can be implemented using bisection methods, Newton's method, factoring, etc.
- The client doesn't care (or need to know) how it is implemented
- The implementation ought to be able to change entirely without impacting the client code (and requiring only relinking)

Design Case Study: Key Word in Context (KWIC)

- “The KWIC [Key Word in Context] index system accepts an ordered set of lines, each line is an ordered set of words, and each word is an ordered set of characters. Any line may be “circularly shifted” by repeatedly removing the first word and appending it at the end of the line. The KWIC index system outputs a listing of all circular shifts of all lines in alphabetical order.”
 - Parnas 1972
- Consider KWIC applied to the title of this slide:

Design Case Study:
Case Study: Design
Study: Design Case
Key Word In Context (KWIC)
Word In Context (KWIC) Key
In Context (KWIC) Key Word
Context (KWIC) Key Word In
(KWIC) Key Word In Context



(KWIC) Key Word In Context
Case Study: Design
Context (KWIC) Key Word In
Design Case Study:
In Context (KWIC) Key Word
Key Word In Context (KWIC)
Study: Design Case
Word In Context (KWIC) Key

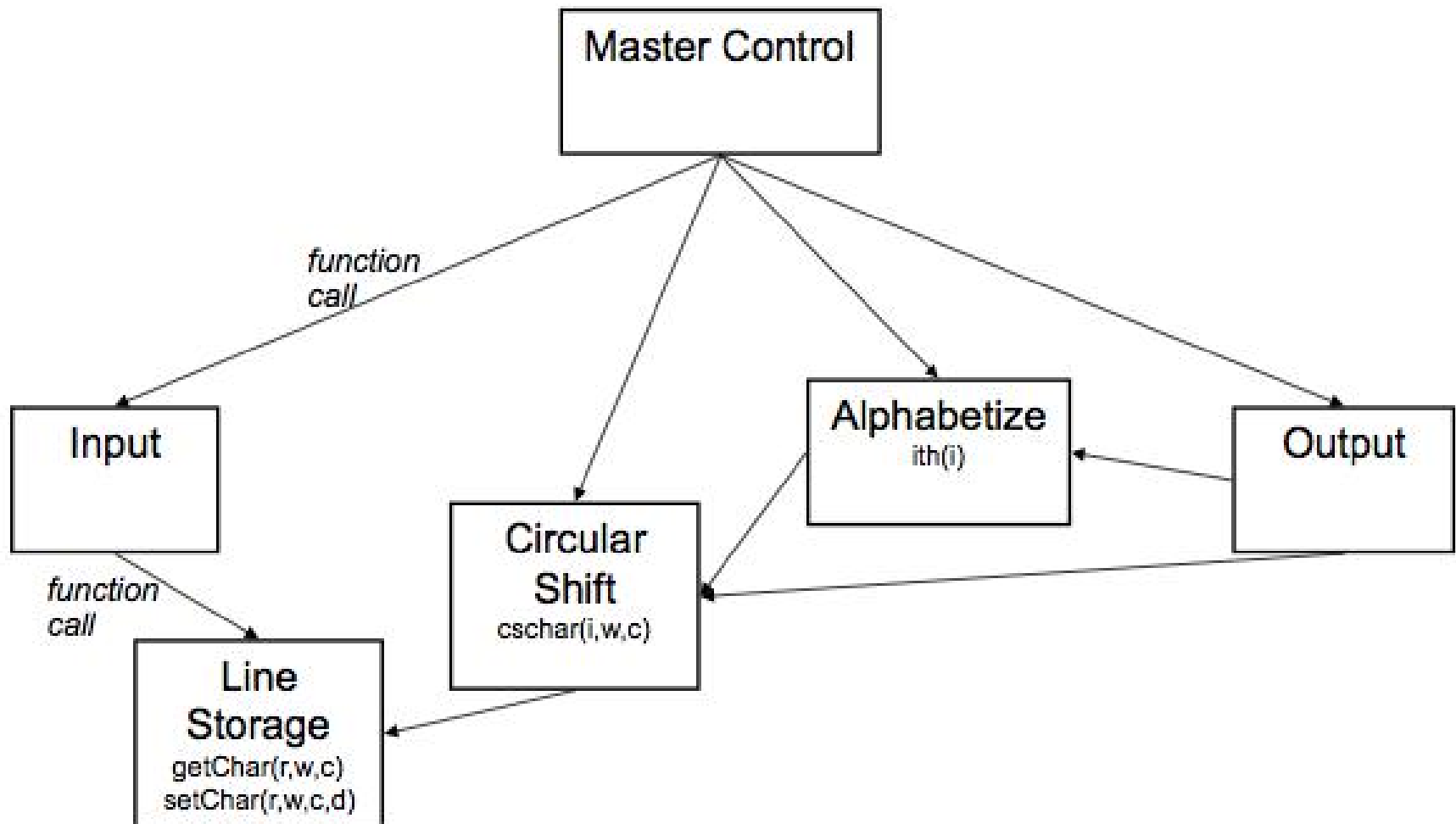
Modularization #1

This is a modularization in the sense meant by all proponents of modular programming. The system is divided into a number of modules with well-defined interfaces; each one is small enough and simple enough to be thoroughly understood and well programmed. Experiments on a small scale indicate that this is approximately the decomposition which would be proposed by most programmers for the task specified.

Modularization #1

Changes	MasterControl	Input	CircularShift	Alphabetizer	Output
InputFormat		X			
Storage		X	X	X	X
Packing characters		X	X	X	X
Index for CircularShift			X	X	X
Search				X	X

KWIC Modularization #2 (Information Hiding)



Modularization #2

- Line storage abstracts the storage/representation of the input
- Circular shift is analogous to the circular shift in modularization #1, but...
 - The module gives the *impression* that we have a line holder creating all of the circular shifts

Modularization #2

Changes	Master Control	Input	Circular Shift	Alphabet izer	Output	LineStorage
InputFormat						
Storage						
Packing characters						
Index for CircularShift						
Search						
Line Storage		X	X	X	X	

KWIC Observations

- Similar at runtime
 - May have identical data representations, algorithms, even compiled code
- Different in code
 - Understanding
 - Documenting
 - Evolving
- The two versions are different in the way they divide work assignments and the interfaces between the modules

But Software Changes...

- “... accept the fact of change as a way of life, rather than an untoward and annoying exception.”
 - Brooks 1974
- “Software that does not change becomes useless over time.”
 - Belady and Lehman
- For successful software projects, most of the cost is in evolving the system, not in initial development
 - Therefore, reducing the cost of change is one of the most important principles in software design

Other Compounding Factors

- Independent development
 - Data formats (in design #1) are more complex than data access interfaces (in design #2)
 - Easier to agree on the interfaces in design #2
 - More work in design #2 is independent (because less is shared)
- Comprehensibility
 - Design of data formats in design #1 depends on the details of each module (and vice versa)
 - More difficult to understand each module in isolation in design #1

Summary: Decomposition Criteria

- Functional decomposition
 - Break down by major processing steps
- Information hiding decomposition
 - Each module is characterized by a design decision it hides from others
 - Interfaces chosen and designed to reveal as little as possible about the hidden secrets

Try to comment #1

```

class LegacyLine {
    public void draw(int x1, int y1, int x2, int y2) {
        System.out.println("line from (" + x1 + ',' + y1 + ")
to ("
    + x2 + ',' + y2 + ')');
    }
}
class LegacyRectangle {
    public void draw(int x, int y, int w, int h) {
        System.out.println("rectangle at (" + x + ',' + y + ")
with width "
    + w + " and height " + h);
    }
}
public class Demo {
    public static void main(String[] args) {
        Object[] shapes = { new LegacyLine(), new
LegacyRectangle() };
        int x1 = 10, y1 = 20, x2 = 30, y2 = 60;
        for (int i = 0; i < shapes.length; ++i) {
            if
(shape[i].getClass().getName().equals("LegacyLine"))
                (LegacyLine) shapes[i].draw(x1, y1, x2, y2);
            else if
(shape[i].getClass().getName().equals("LegacyRectangle"))
                (LegacyRectangle) shapes[i].draw(Math.min(x1, x2),
Math.min(y1, y2), Math.abs(x2 - x1), Math.abs(y2 -
y1));
        }
    }
}

```


Try to comment #2

```
interface Shape {
    void draw(int x1, int y1, int x2, int y2);
}

class Line implements Shape {
    private LegacyLine ll = new LegacyLine();
    public void draw(int x1, int y1, int x2, int y2) {
        ll.draw(x1, y1, x2, y2);
    }
}

class Rectangle implements Shape {
    private LegacyRectangle lr = new LegacyRectangle();
    public void draw(int x1, int y1, int x2, int y2) {
        lr.draw(Math.min(x1, x2), Math.min(y1, y2),
            Math.abs(x2 - x1), Math.abs(y2 - y1));
    }
}

public class Demo {
    public static void main(String[] args) {
        ArrayList<Shape> shapes = new ArrayList<Shape>();
        shapes.add(new Line());
        shapes.add(new Rectangle());

        int x1 = 10, y1 = 20, x2 = 30, y2 = 60;
        for (Shape s : shapes)
            s.draw(x1, y1, x2, y2);
    }
}
```

Information Hiding Summary

- Decide what design decisions are likely to change and which are likely to be stable
- Put each design decision likely to change in its own module
- Assign each module an interface that hides the decision likely to change and exposes only stable design decisions
- Ensure that the clients of a module depend only on the stable interface and not the implementation
- Benefit: *if* you can correctly predict what may change and hide information properly, each change will affect one module

Types of Secrets

- Algorithms (procedural abstraction)
- Data representations (abstract data types)
- Characteristics of a hardware device (virtual machines, hardware abstraction layers, etc.)
 - E.g., whether a thermometer measures in Fahrenheit or Celsius
- Where information is acquired
 - E.g., which search engine is used
- User interface (e.g., model-view pattern)
- What are other examples?
 - What about in the context of your projects?

QUESTIONS?
