

# Clean Code

Github: <https://bit.ly/48XKE5t>

## It's different



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Let there be no doubt that object-oriented design is fundamentally different than traditional structured design approaches. It requires a different way of thinking about decomposition, and it produces software architectures that are largely outside the realm of structured design culture. – Grady Booch

Many people tell the story of the CEO of a software company who claimed that his product would be object oriented because it was written in C++. Some tell the story without knowing that it is a joke.

## Does OO benefit?

- Lesser Code
- Faster
- Easier Maintenance

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The product of object thinking is software that manifests simplicity and composability, which lead, in turn, to adaptability, flexibility, and evolvability.

A 1 million-line program, written in with non-OO concepts can be duplicated in OO with 100K LOC or fewer.

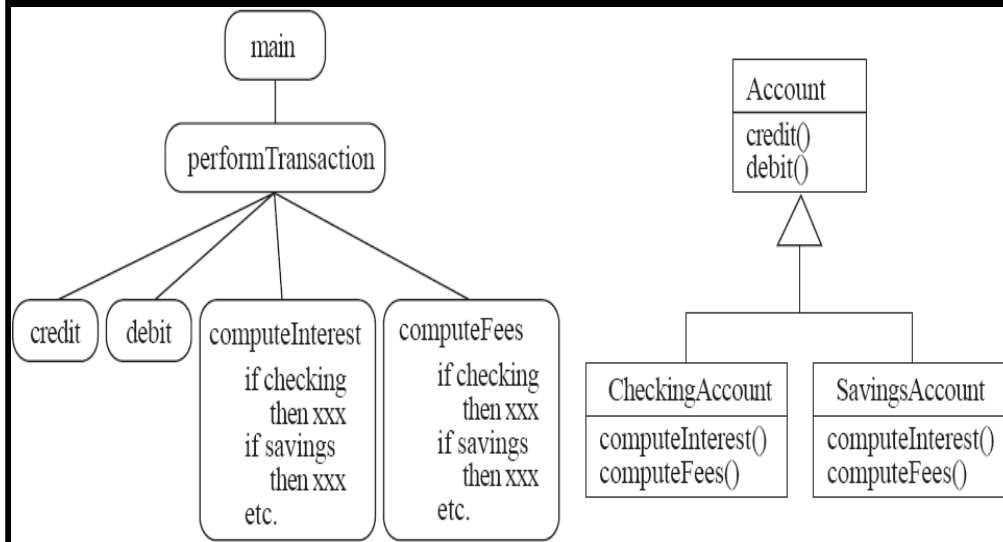
Time to delivery is reduced by at least 50% and usually 70%.

Project that took 2 years can complete in 8 to 12 months.

Exceptions:

- Device driver written in 100 lines of assembly
- Internet search engine needs “database thinking”
- Network Router (I/O performance)
- Mobile phone (memory footprint)
- Embedded Sensor (power consumption)

# How is OO different?



Think like an Object and not like a Computer.

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How is object thinking different from thinking like a computer?

Object thinking involves a very different means of solution – a cooperating community of virtual persons

Object thinking focuses our attention on the problem space rather than the solution space

# OO Design is an Art



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OOAD books and classes can only enhance the innate talents of individuals and make them the best OO engineers they can be.

The education of artists is not focused on technique, process or tools.

The majority of an art education combines ideas, history, appreciation, experience and constructive criticism.

## Different

- Advocacy of a local rather than global focus
- Practitioners of rapid prototyping instead of structured development



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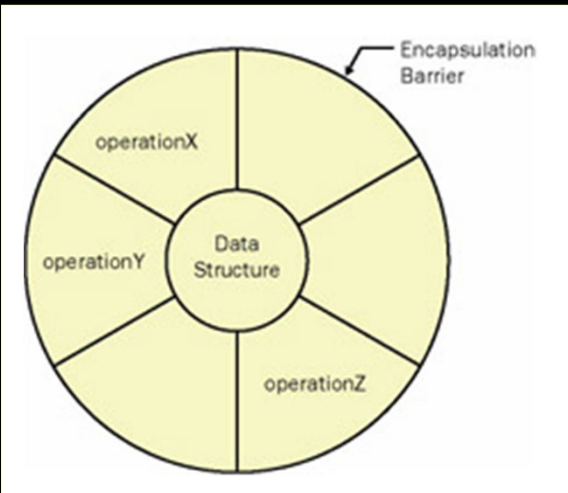
Collaborative rather than imperial management style

OOD -


Commitment to design based on coordination and cooperation rather than control

Driven by internal capabilities instead of conforming to external procedures.

# Representation of an Object



or



Objects are not something that we do;  
objects are a way that we think.

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In a data-driven approach, the attributes of an object are discovered first and then responsibilities are meted out as a function of which object holds which data.

A behavioral approach mandates the assignment of responsibilities first. Only when you are satisfied with the distribution of responsibilities among your objects are you ready to make a decision about what they need to know to fulfill those responsibilities and which parts of that knowledge they need to keep as part of their structure—in instance variables or attributes.

This is the single biggest difference in definition between data-driven and behavior-driven or responsibility-driven approaches to objects.

Responsibilities are not functions, although there is a superficial resemblance. The former reflects expectations in the domain—the problem space—while the latter reflects an implementation detail in the solution space—the computer program.

Our goal during discovery is object definition, not object specification. Definition means we want to capture how the object is defined by those using it, what they think of that object, what they expect of it when they use it, and the extent to which it is similar to and different from other objects in the domain. Specification will come later (maybe 30 seconds later if you are doing XP and working on a single object), when we allow ourselves to consider how this object might be implemented (simulated) in software.

It's a major mistake, from an object thinking perspective, to define objects in terms of an application instead of a domain.

# Decide Classes

- How to decide what should be a class?
  - Nouns
  - Value is a group of items.
  - Functions associated with an item.



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Q022: telLocalNumber

Q01: IsSameString

Class should be highly cohesive

A Class should have a single well focused purpose.

A Class should do one thing and do it well.



## Find the classes

- Selling soft drinks on a vending machine.
  - Software will control the functions of the vending machine.
  - First the user enters some money. The machine displays the money entered so far. The products that can be bought, light up. The user chooses his option. The vending machine dispenses the product and the change.

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Answer: VendingMachine, MoneyBox, Screen, PriceList, SoftDrink, SoftDrinkList, SoftDrinkDispenser, Safe

## How to find classes?

- Object thinking emphasizes the need to *understand the domain first*.



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Simulation of a problem domain drives object discovery and definition

A truism of software development is that the most costly mistakes are made the first day. Why?

Simply for a lack of knowledge.

Developers anticipate how the computer is going to implement your software before trying to understand how the software should simulate some part of the domain in which it is going to be used.

It's never appropriate to tell yourself, "This is what the code will look like, so I need an object to hold these parts of the code, and another to hold these parts, and another to make sure these two do what they are told to do when they are told to do it," which is precisely what structured development tempts you to do.

Perhaps the greatest benefit of object thinking is that of helping you start off in the right direction. Object thinking does this by emphasizing the need to *understand the domain first*.

Software expertise does not trump domain expertise. The longer a software developer works in a domain, the more effective her software work will be.

Most books and methods addressing how to do object development recommend that the object discovery process begin with underlining the nouns (names) in a domain or problem description. While it is true that many of those nouns will indeed turn out to be viable objects, it is unlikely that any written description will be

sufficiently complete or accurate to meet the needs of domain

# Metaphor

- Object is like a person.
  - Both are specialists and lazy
  - Both don't like to be micromanaged.
  - Both take responsibilities

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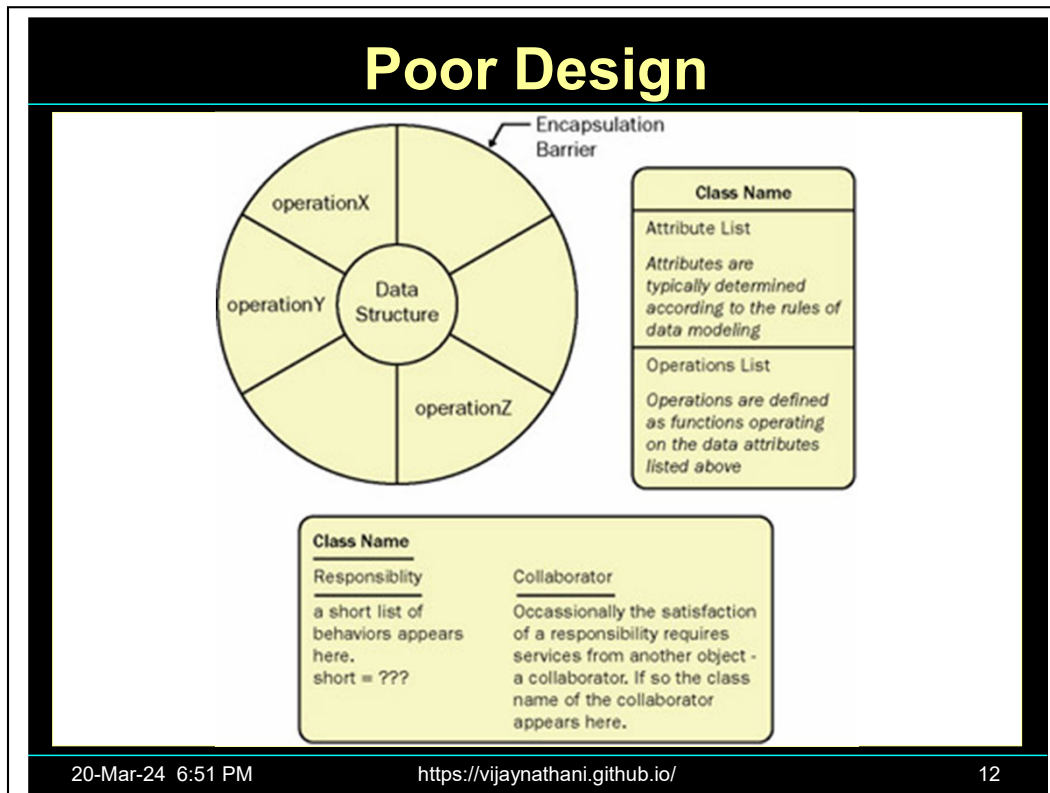
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Distributed cooperation and communication must replace hierarchical centralized control as an organizational paradigm. E.g. A traffic signal and cars.

Like people, software objects are specialists and lazy. A consequence of both these facts is the distribution of work across a group of objects. Take the job of adding a sentence to a page in a book. Granted, it might be quite proper to ask the book, "Please replace the sentence on page 58 with the following." (The book object is kind of a spokesperson for all the objects that make up the book.) It would be quite improper, however, to expect the book itself to do the work assigned. If the book were to do that kind of work, it would have to know everything relevant about each page and page type that it might contain and how making a simple change might alter the appearance and the abilities of the page object. Plus the page might be offended if the book attempted to meddle with its internals.

The task is too hard (lazy object) and not the book's job (specialist object), so it delegates—merely passes to the page object named #58 the requested change. It's the page object's responsibility to carry out the task. And it too might delegate any part of it that is hard—to a string object perhaps.

Objects, like the people we metaphorically equate them to, can work independently and concurrently on large-scale tasks, requiring only general coordination. When we ask an object collective to perform a task, it's important that we avoid micromanagement by imposing explicit control structures on those objects. You don't like to work for a boss who doesn't trust you and allow you to do your job, so why should your software objects put up with similar abuse?



Shown above are “soccer bar”, animated data entry and CRC card. All three are not very useful.

They depict what is to be built instead of what is to be modeled.

Object discovery and specification must be at domain level.

# Metaphors

- Software is a Theater, Programmer is a director
- Ants, not Autocrats



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Q57srp – Students

Q58srp – Servers

Hierarchical and centralized control is the anathema in OO. Complex systems are characterized by simple elements, acting on local knowledge with local rules, give rise to complicated patterned behavior. Object can inherit like a person.

For example, suppose an airplane object has a responsibility to report its location. This is a hard task because the location is constantly changing; a location is a composite structure (latitude, longitude, altitude, direction, speed, and vector); the values of each part of that structure come from a different source; and someone has to remember who asked for the location and make sure it gets back to them in a timely fashion. If the task is broken up so that

- The airplane actually returns a location object to whoever asked for it after appending its ID to the location so that there is no confusion about who is where. (We cannot assume that our airplane is the only one reporting its location at any one time.)

- An instrument cluster keeps track of the instruments that must be asked for their current values and knows how to ask each one in turn for its value (a collection iterating across its contents).

- An instrument merely reports its current value.
  - A location object collects and returns a set of label:value pairs (altitude:15,000 ft.).
- None of the objects do anything particularly difficult, and yet collectively they solve a complicated problem that would be very hard for any one of them to accomplish individually.

# Encapsulation

- Encapsulation
  - A Class/Bounded Context/Library should be as shy as possible



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It is about managing complexity

Put state information in the class that works on it. Collaborating classes are unaware of the internal state of this object.

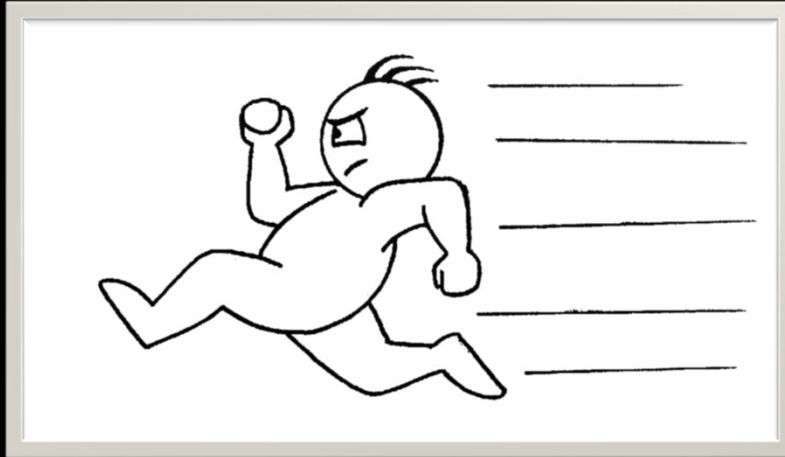
Keep a variable/function private, if possible. Use minimum visibility.

Every module should have a secret. If it does not have a secret, why does it exist?



# Polymorphism

- Polymorphism
  - Interfaces and overridden functions



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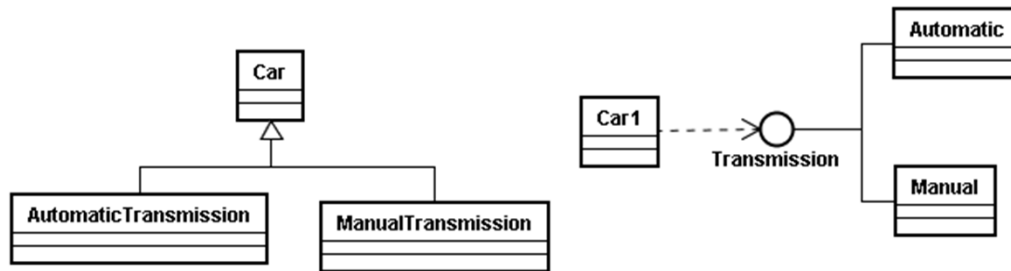
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Q30 , Q40, Q43, Q36, Q41

# Inheritance vs. Delegation

- Which is better?



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## Composition Advantages

Contained objects are accessed by the containing class solely through their interfaces

"Black-box" reuse, since internal details of contained objects are not visible

Good encapsulation

Fewer implementation dependencies

Each class is focused on just one task

The composition can be defined dynamically at run-time through objects acquiring references to other objects of the same type

## Composition Disadvantages

Resulting systems tend to have more objects

Interfaces must be carefully defined in order to use many different objects as composition.

## Prefer Composition/Interfaces to Inheritance.

Composition implies has-a or uses-a relationship.

Inheritance implies is-like-a relationship.

While using inheritance, the Liskov's Substitution Principle must not be violated.

Also, Avoid deep inheritance trees

As far as possible, it is preferable to inherit from an abstract class.

#### Generalization Advantages

New implementation is easy, since most of it is inherited

Easy to modify or extend the implementation being reused

#### Generalization Disadvantages

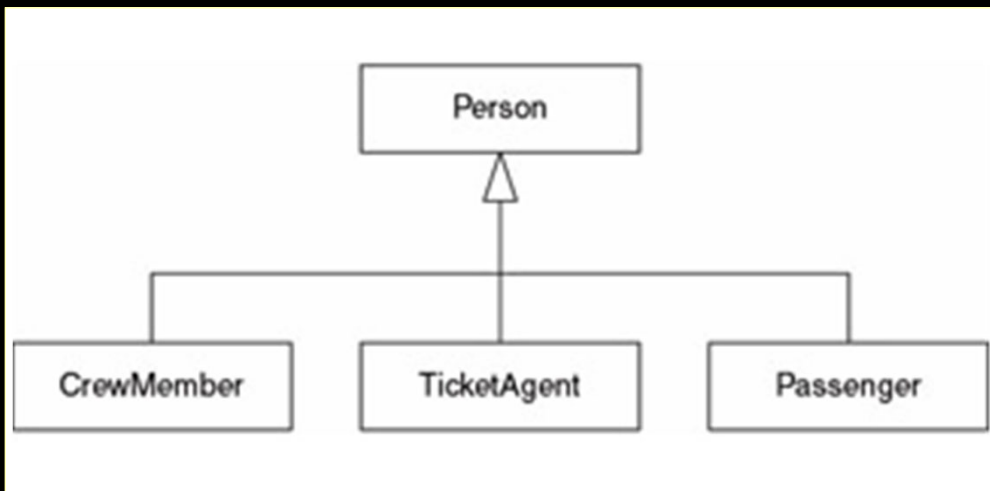
Breaks encapsulation, since it exposes a subclass to implementation details of its super class

"White-box" reuse, since internal details of super classes are often visible to subclasses

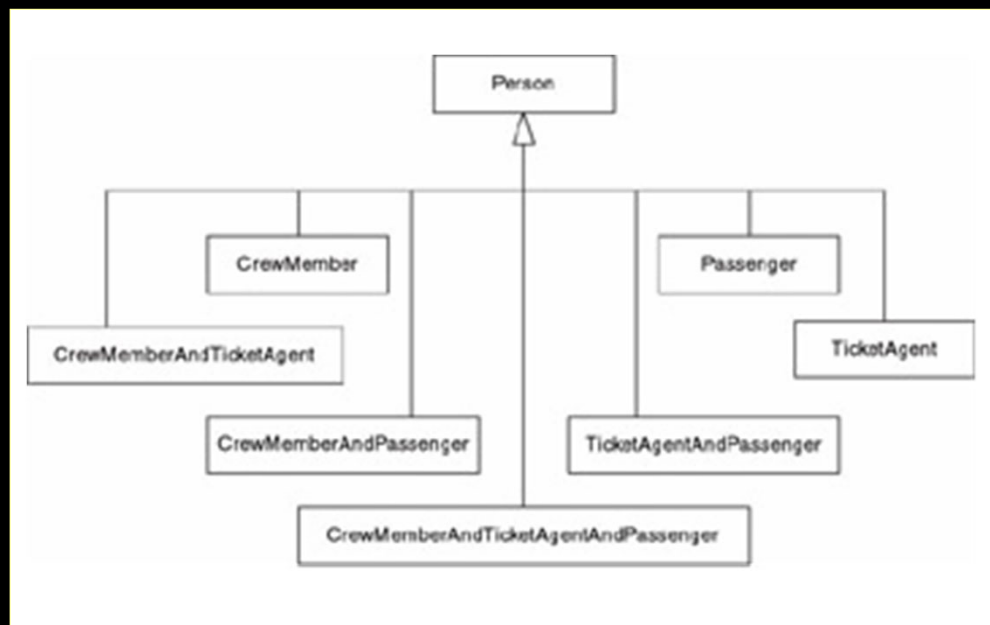
Subclasses may have to be changed if the implementation of the super class changes

Implementations inherited from super classes can not be changed at runtime

# Airline Reservation System



## Same Person – Multiple roles

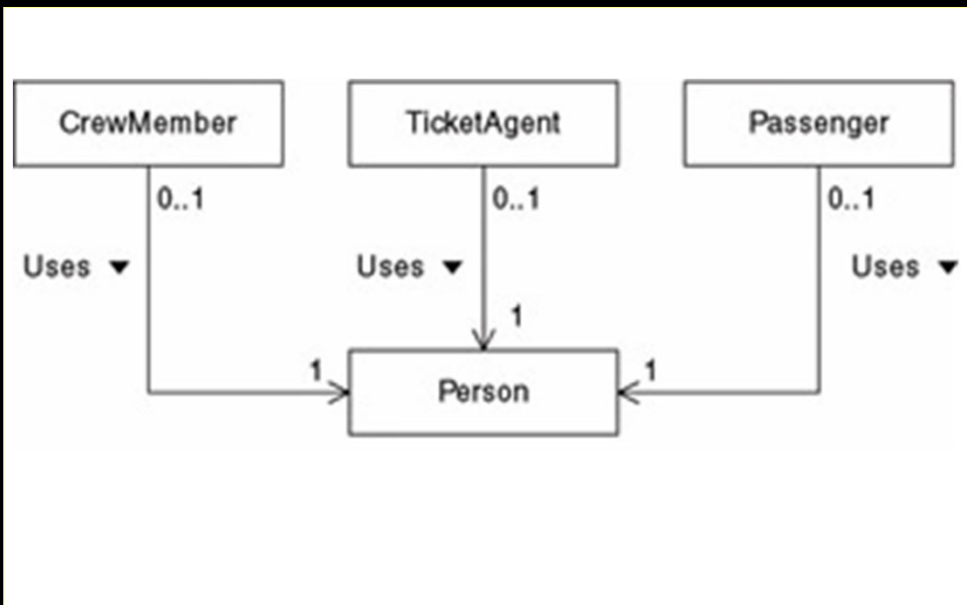


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## A person can change roles Now



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# Stack is not ArrayList

```
class Stack extends ArrayList {
    private int topOfStack = 0;
    public void push( Object article ) {
        add( topOfStack++, article ); }
    public Object pop() {
        return remove( --topOfStack ); }
    public void pushMany( Object[] articles ) {
        for( int i = 0; i < articles.length; ++i )
            push( articles[i] ); }
}

Stack aStack = new Stack();
aStack.push("1");
aStack.push("2");
aStack.clear(); //Error
```

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Even a class as simple as this one has problems. Consider what happens when a user leverages inheritance and uses the ArrayList's clear() method to pop everything off the stack.

The code compiles just fine, but since the base class doesn't know anything about the index of the item at the top of the stack (topOfStack), the Stack object is now in an undefined state. The next call to push() puts the new item at index 2 (the current value of the topOfStack), so the stack effectively has three elements on it, the bottom two of which are garbage.

One (hideously bad) solution to the inheriting-undesirable-methods problem is for Stack to override all the methods of ArrayList that can modify the state of the array to manipulate the stack pointer. This is a lot of work, though, and doesn't handle problems such as adding a method like clear() to the base class after you've written the derived class.

To solve the problem, use delegation:

```
class Stack {
    private int topOfStack = 0;
    private ArrayList theData = new ArrayList();
    public void push( Object article ) {
        theData.add( topOfStack++, article );
    }
    public Object pop() {
        return theData.remove( --topOfStack );
    }
    public void pushMany( Object[] articles ) {
        for( int i = 0; i < articles.length; ++i )
            push( articles[i] );
    }
    public int size() // current stack size.
    { return theData.size(); }
}
```

## What's the output?

```
public class cil<T> extends HashSet<T> {
    private int addCount = 0;
    public cil() {}
    public cil (Collection<T> c) {super(c);}
    public cil (int initCap, float loadFactor) {
        super(initCap, loadFactor); }
    @Override public boolean add(T o) {
        addCount++; return super.add(o); }
    @Override public boolean addAll(
        Collection<? extends T> c) {
        addCount += c.size(); return super.addAll(c);
    }
    public int getAddCount() {return addCount; }
    public static void main(String[] args) {
        cil<String> s = new cil<String>();
        s.addAll(Arrays.asList(new String[]
            {"Snap", "Crackle", "Pop"}));
        System.out.println(s.getAddCount()); } }
```

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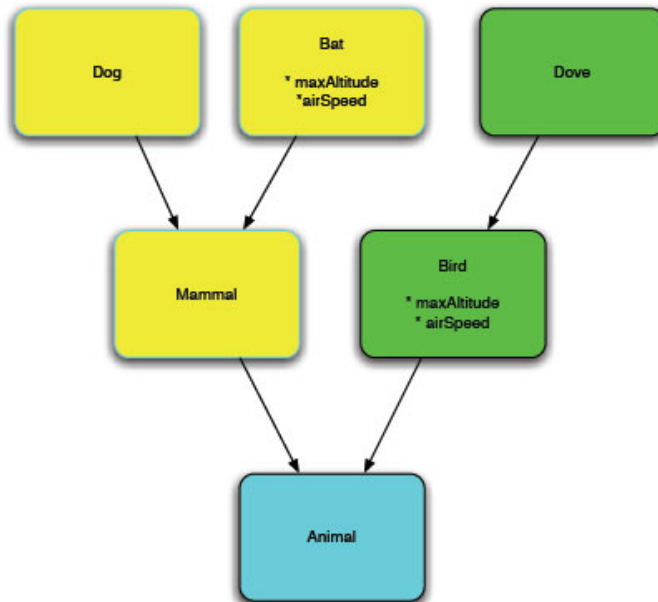
The output comes as 6 instead of 3.

The class should implement the interface Set and use HashSet internally.

The **fragile base class problem** is a fundamental architectural problem of [object-oriented programming](#) systems where base classes ([super classes](#)) are considered "fragile" because seemingly safe modifications to a base class, when inherited by the [derived classes](#), may cause the derived classes to malfunction. The programmer cannot determine whether a base class change is safe simply by examining in isolation the methods of the base class.



## Bat cannot be a Bird?



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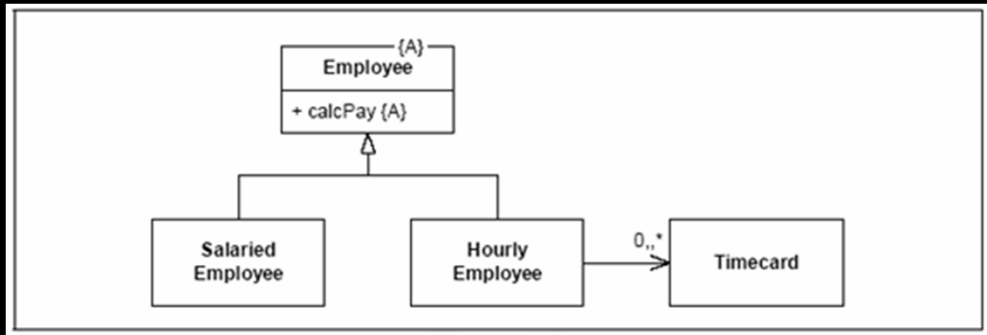
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Bat has a flying capability  
Dove has a flying capability  
is better than  
Bat is a flying creature  
Dove is a flying creature

# Liskov Substitution Principle

- All derived classes must be substitutable for their base class.



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Now we have a Category of Employee – “Volunteer”, who does not receive salary  
E.g. Ellipse and Circle. If some class sets attributes and prints major and minor axis hard coded then it is a problem.

The Liskov Substitution Principle (LSP) makes it clear that the ISA relationship is all about behavior.

Violation of this law leads to usage of instanceof operator or throwing of exceptions for certain functions in a class.

E.G Deriving Square from Rectangle violates this principle because Rectangle has two functions: setWidth and setHeight.

E.g. CarOwner being derived from Car and Person.

Inheritance should preferably be done from abstract classes with minimal code.

## Does Subclass make sense?

- Subclass only when is-a-kind-of relationship.
- Bad
  - Properties extends HashTable
  - Stack extends Vector
- Good
  - Set extends Collection

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Assume that you have an inheritance hierarchy with Person and Student. Wherever you can use Person, you should also be able to use a Student, because Student is a subclass of Person. At first this might sound like that's always the case automatically, but when you start thinking about reflection (reflection is a technique for being able to programmatically inspect the type of an instance and read and set its properties and fields and call its methods, without knowing about the type beforehand), for example, it's not so obvious anymore. A method that uses reflection for dealing with Person might not expect Student.

The reflection problem is a syntactical one. Martin uses a more semantically example of Square that is a Rectangle. But when you use SetWidth() for the Square, that doesn't make sense, or at least you have to internally call SetHeight() as well. A pretty different behavior from what Rectangle needs.

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Design & Document for inheritance

Otherwise prohibit inheritance

Conservative Policy:

All concrete classes are final

Never override a concrete function.

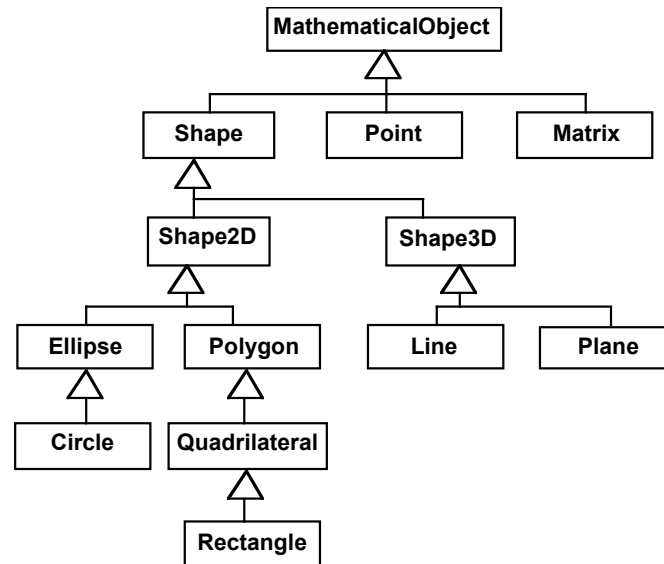
Bad

Many concrete classes in Java are not final

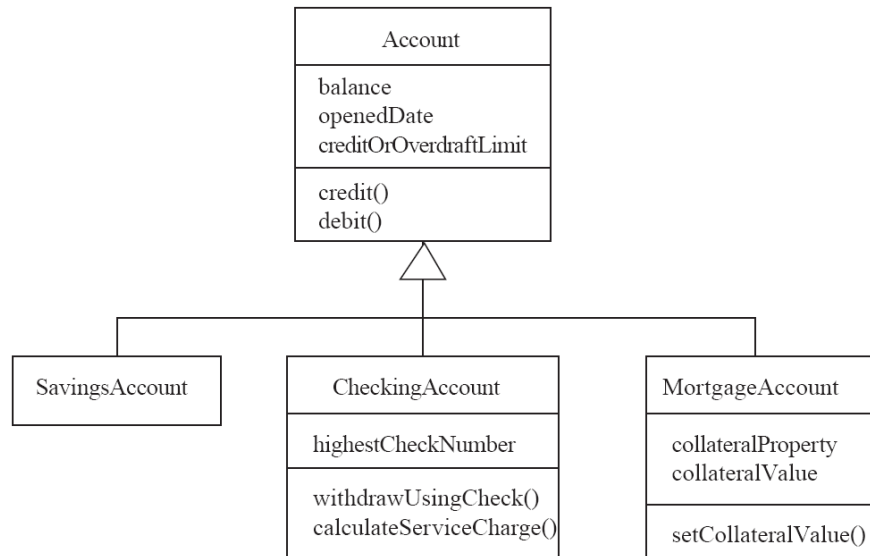
Good

AbstractSet, AbstractMap

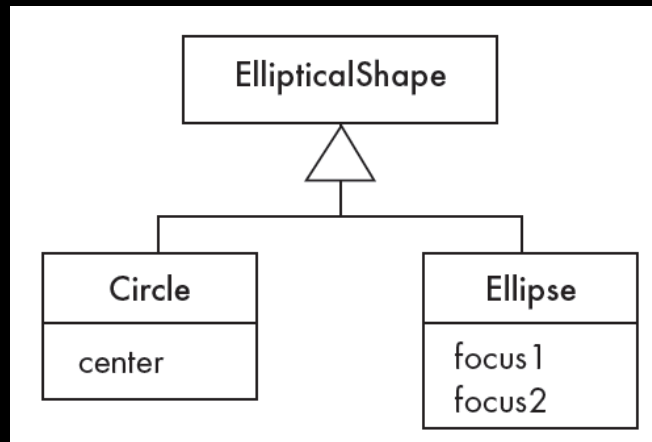
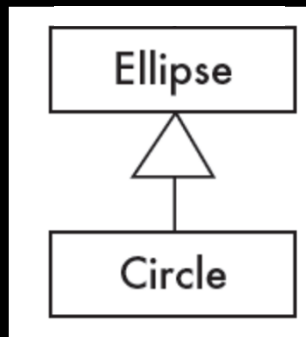
# Avoid Deep Inheritance



## All Inherited Features should make sense in Subclasses



# Reorganize



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# Inheritance rules

- Prefer Delegation over Inheritance
- All instance variables and functionality of base class should be applicable to derived class
- Prefer interfaces to Abstract base class
- Liskov Substitution principle
- Avoid deep inheritance hierarchy
- Prefer to extend abstract classes, if inheritance has to be used.



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Q72, Q31, Q71, Q52, Q54, Q74, Q75

Avoid deep Inheritance Hierarchy: Q76



## Guidelines

- DRY



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Q021, Q11, Q33, Q37, Q34, Q35

There are three numbers in software: 0, 1, and infinity. 0 represents the things we do not do in a system (we do those for free). 1 represents the things we do once and only once. But at the moment we do something twice, we should treat it as infinitely many and create cohesive services that allow it to be reused.

## Classes in an Application

- Many simple classes means that each class
  - encapsulates less of overall system intelligence
  - is more reusable
  - is easier to implement
- A few complex classes means that each class
  - encapsulates a large portion of system intelligence
  - is less likely to be reusable
  - is more difficult to implement

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Lots of little pieces

Classes are cohesive

Methods do only one thing.

## Guidelines

- A class should have less than 50 lines
- Most functions should be less than or equal to 5 lines.
  - A function taking more than 3 arguments should be rare and justified specially.

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Note: On a Home PC - 1 Million function calls take 8 milliseconds and 1 Million objects are created in 23 milliseconds

## Some Real Examples

Tool	Files	Lines/file (avg)	LOC/file (avg)
JUnit	88	71	39
Hibernate	1063	90	72
Eclipse	14,620	153	106
DomainObjects for .NET	422	164	98
Compiere ERP & CRM	1191	163	114
Hsqldb	290	503	198

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Small Classes: Q56, Q59

GoogleTest is a C++ project. Most functions are smaller than 10 lines.

CLOC tool reported

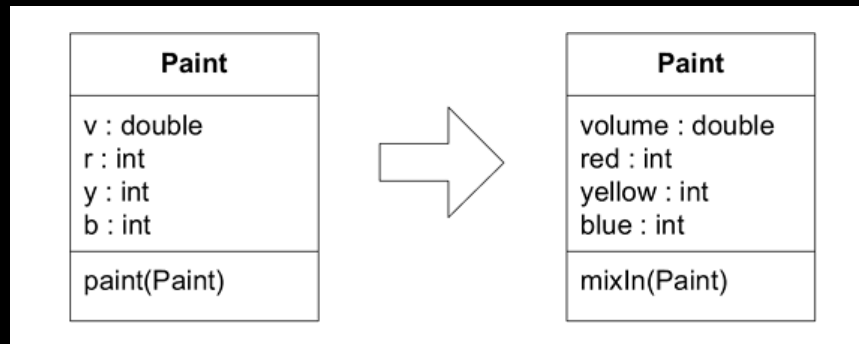
Language	files	blank	comment	code
C++	106	8876	11299	36926
C/C++ Header	49	3732	9719	15164

# Challenge

- A class has a huge constructor.
- What will you do?

## Rule: Don't abbreviate

- Code should be self documenting.
  - Tools: SonarQube, Codepro.



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Public API's have to be documented i.e. every class, function, interface, exceptions. Mutable objects that can / cannot be modified.

This is possible by choosing the right variable and function names.

Comments are secondary because they tend to lie

Java: Checkstyle, PMD

C#: SytleCop+, FxCop, Simian, Ncover, NDepend for cyclomatic complexity.

C++: Simian or PMD CPD for duplication, coverity for source code analysis

JavaScript: JSHint

```
public List<int[]> getThem() {  
    List<int[]> list1 =  
        new ArrayList<int[]>>();  
    for (int[] x : theList)  
        if (x[0] == 4)  
            list1.add(x);  
    return list1;  
}
```



```
} public List<Cell> getFlaggedCells() {  
    List<Cell> flaggedCells =  
        new ArrayList<Cell>();  
    for (Cell cell : gameBoard)  
        if (cell.isFlagged())  
            flaggedCells.add(cell);  
    return flaggedCells;  
}
```

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```
class DtaRcrd102 {  
    private Date genymdhms;  
    private Date modymdhms;  
    private final String pszqint = "102";  
    /* ... */  
};
```



```
class Customer {  
    private Date generationTimestamp;  
    private Date modificationTimestamp;;  
    private static final String  
        RECORD_ID = "102";  
    /* ... */  
};
```



# Guidelines

- Classes and objects should have noun or noun phrase names like Customer, WikiPage, Account, and AddressParser.
  - Avoid words like Manager, Processor, Data, or Info in the name of a class.
  - A class name should not be a verb.
- Methods should have verb or verb phrase names like postPayment, deletePage, or save.

# Values

- Communication
- Simplicity
- Flexibility

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Mostly they complement each other.

Code communicates well, when a reader can understand it, modify it and use it.

Eliminating excess complexity, makes the program easier to understand, modify and use.

Flexibility means that the program can be changed.

## Code should readable

- Any fool can write code that a computer can understand. Good programmers write code that humans can understand. – Martin Fowler

```
▪ Calendar c=Calendar.getInstance();  
  c.set(2005,Calendar.NOVEMBER, 20);  
  Date t = c.getTime(); OR  
▪ Date t = november(20, 2005) ;  
  public Date november (  
      int day, int year)  { ... }
```

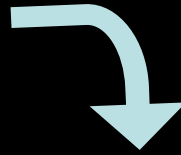
# Compare

```
void process() {  
    input();  
    count++;  
    output();  
}
```

```
void process() {  
    input();  
    tally();  
    output();  
}  
private void tally() {  
    count++;  
}
```

# Compose Method Pattern

```
public void add(Object element) {  
    if (!readOnly) {  
        int newSize = size + 1;  
        if (newSize > elements.length) {  
            Object[] newElements =  
                new Object[elements.length + 10];  
            for (int i = 0; i < size; i++)  
                newElements[i] = elements[i];  
            elements = newElements;  
        }  
        elements[size++] = element;  
    }  
}
```



```
public void add(Object element) {  
    if (readOnly)  
        return;  
    if (atCapacity())  
        grow();  
    addElement(element);  
}
```

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## Benefits and Liabilities

- +Efficiently communicates what a method does and how it does what it does.
- +Simplifies a method by breaking it up into well-named chunks of behavior at the same level of detail.
- Can lead to an overabundance of small methods.
- Can make debugging difficult because logic is spread out across many small methods.

# Improve

```
flags |= LOADED_BIT;
```

- Solution: Extract to a message

```
void setLoadedFlag() {  
    flags |= LOADED_BIT;  
}
```

## Improve Code

```
// Check to see if the employee
// is eligible for full benefits
if ((employee.flags & HOURLY_FLAG)
    && (employee.age > 65)) ...

if (employee.
    isEligibleForFullBenefits())
```

# Goal

- Communicate better with our code
- Reduce cost

$$\text{Cost}_{\text{Maintain}} = \text{Cost}_{\text{Understand}} + \text{Cost}_{\text{Change}} + \text{Cost}_{\text{Test}} + \text{Cost}_{\text{Deploy}}$$

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Falls between design patterns and Java language manual  
Isolate the concurrent portions of the code.

Most programs follow a small set of laws:

- Programs are read more often than they are written
- There is no such thing as “done”. Much more investment will be spent in modifying programs than in developing them initially.
- They are structured using a basic set of state and control flow concepts
- Readers need to understand programs in detail and in concept

Cost to understand code is high. So maintenance is costly. Code will need to change in unanticipated ways.

When code is clear we have fewer defects and smoother development also.



# Improve

- Function signature  
`void render(boolean isSuite)`
- Remove boolean variables from functions.  
Have two functions.

```
void renderForSuite()  
void renderForSingleTest()
```

## Avoid Long parameter lists

- Long parameter list means more chances of an error.
  - `CreateWindow` in `Win32` has 11 parameters.
- How to solve it?

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Break the method or

Create Helper class to hold parameters

# Improve

```
class Board {  
    ...  
    String board() {  
        StringBuffer buf = new StringBuffer();  
        for(int i = 0; i < 10; i++) {  
            for(int j = 0; j < 10; j++)  
                buf.append(data[i][j]);  
            buf.append("\n" );  
        }  
        return buf.toString();  
    }  
}
```

## Only one level of indentation per method

```
Class Board {  
    ...  
    String board() {  
        StringBuffer buf = new StringBuffer();  
        collectRows(buf);  
        return buf.toString();  
    }  
    void collectRows(StringBuffer buf) {  
        for(int i = 0; i < 10; i++)  
            collectRow(buf, i);  
    }  
    void collectRow(StringBuffer buf, int row) {  
        for(int i = 0; i < 10; i++)  
            buf.append(data[row][i]);  
        buf.append("\n" );  
    }  
}
```

?

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Self documenting code

Q20 – inch; Q06 – NO\_GROUPING; Q07 – addHoliday; Q21 – full name in English;  
Q22 – complexPassword; Q23 – TokenStream; Q25 - orderItems

## Good Comments?

```
String text = ""'bold text'"";
ParentWidget parent = new BoldWidget(
    new MockWidgetRoot(), ""'bold text'"");
AtomicBoolean failFlag = new AtomicBoolean();
failFlag.set(false);
//This is our best attempt to get a race condition
//by creating large number of threads.
for (int i = 0; i < 25000; i++) {
    WidgetBuilderThread widgetBuilderThread = new
        WidgetBuilderThread(widgetBuilder, text,
            parent, failFlag);
    Thread thread = new Thread(widgetBuilderThread);
    thread.start();
}
assertEquals(false, failFlag.get());
```

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Comment to

- explain WHY we are doing something?
- Also for external documentation. Javadocs public API
- To give warnings: e.g. Don't run unless you want to kill this program.
- Todo comments

## Find the flaw

```
if (deletePage(page) == E_OK)
    if (registry.deleteReference(page.name) == E_OK)
        if ( configKeys.deleteKey(
            page.name.makeKey()) == E_OK)
            logger.log("page deleted");
        else
            logger.log("configKey not deleted");
    else
        logger.log ("deleteReference ... failed");
try {
    deletePage(page);
    registry.deleteReference(page.name);
    configKeys.deleteKey(
        page.name.makeKey());
} catch (Exception e) {
    logger.log(e.getMessage()); }
```

# Samurai Principle

- Throw exception if any error occurs.



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## Compare

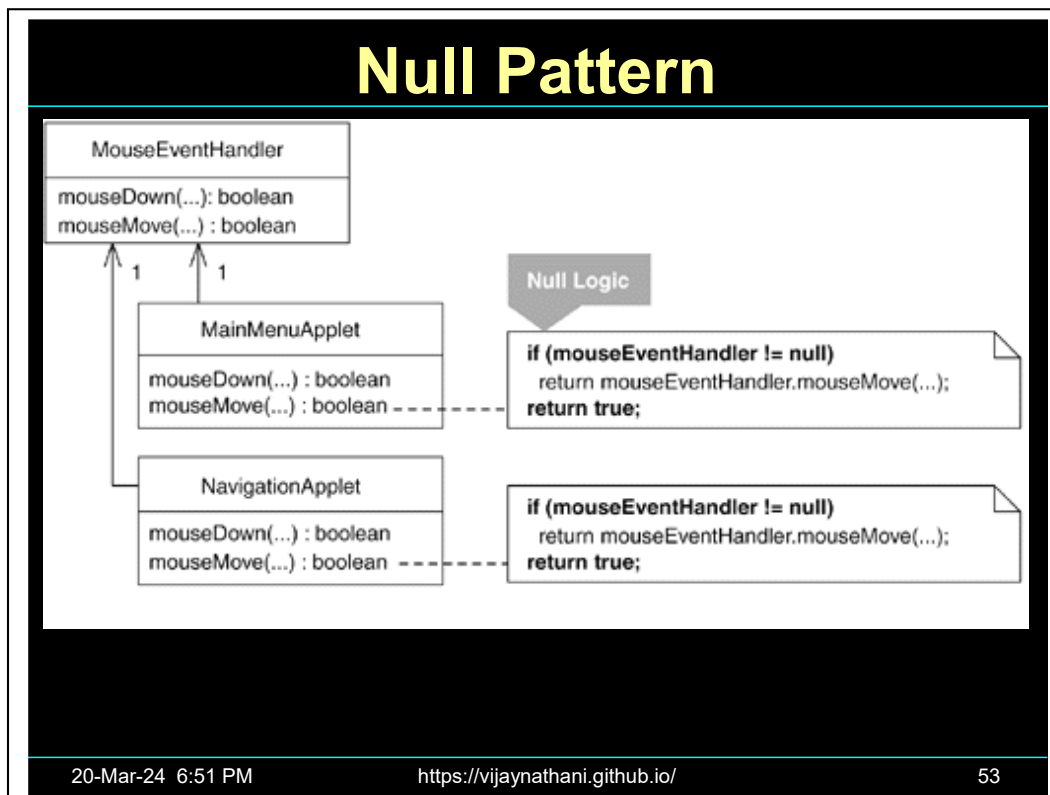
```
List<Employee> employees = getEmployees();  
if (employees != null) {  
    for (Employee e : employees)  
        totalPay += e.getPay();  
}
```



```
List<Employee> employees = getEmployees();  
for( Employee e : employees)  
    totalPay += e.getPay();
```

Java has `Collections.emptyList()` for this. It is immutable.





## Null pattern

Avoid NullPointerException in code

Return "" instead of null for String class

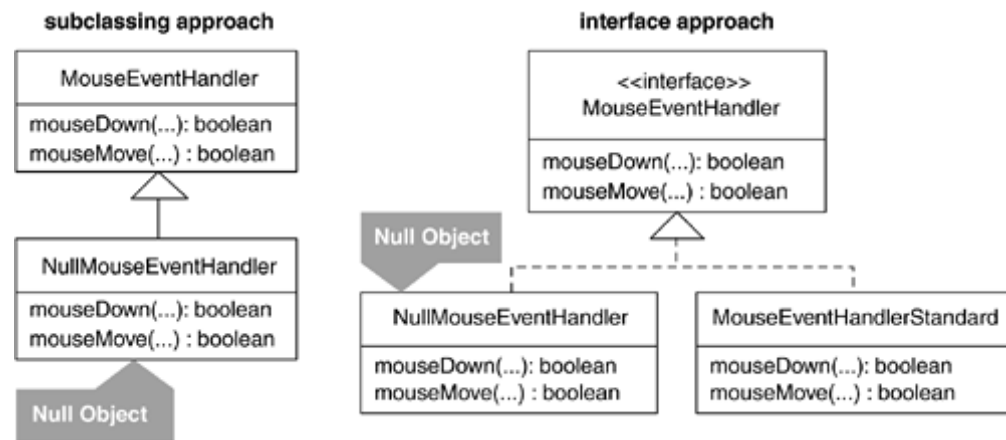
Return an array with zero elements instead of null.

=====

### Benefits and Liabilities

- + Prevents null errors without duplicating null logic.
- + Simplifies code by minimizing null tests.
- Complicates a design when a system needs few null tests.
- Can yield redundant null tests if programmers are unaware of a Null Object implementation.
- Complicates maintenance. Null Objects that have a superclass must override all newly inherited public methods.

# Null Object by Interface



## Guideline

- Unless a method declares in its documentation that null is accepted as a parameter or can be returned from a method as its result, then the method won't accept it or it will never return it.
- Return/Accept Optional object instead of null.

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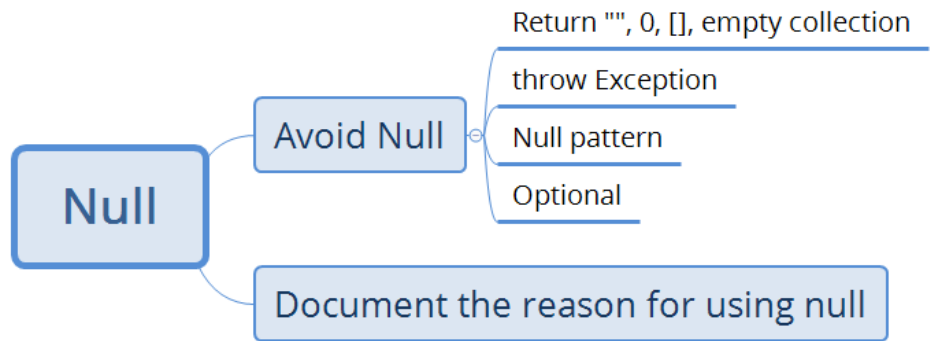
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Optional class is present in Java 8. If you are using older versions of Java, then it is also present in Guava library.

Optional has been coded for C# and stored in same directory other examples. It is also present is an open source library <https://github.com/nlkl/Optional>

Optional is present in C++17, not in older versions. A Demo program is Training1 project.

# Guideline



## Guidelines

- Prefer long to int and double to float to reduce errors.
- Avoid literal constants other than “”, null, 0 and 1.

## Constants

```
for (int j=0; j<34; j++) {  
    s += (t[j]*4)/5;  
}
```



```
int realHoursPerIdealDay = 4;  
const int WORK_DAYS_PER_WEEK = 5;  
int sum = 0;  
for (int j=0; j < NUMBER_OF_TASKS; j++) {  
    int realTaskDays = taskEstimate[j] *  
        realHoursPerIdealDay;  
    int realTaskWeeks = realTaskDays /  
        WORK_DAYS_PER_WEEK;  
    sum += realTaskWeeks;  
}
```

?

Q32 – FoodSalesReport.

## Guidelines

- An interface should be designed so that it is easy to use and difficult to misuse.



## API should be intuitive

- Size of String

```
myString.length(); //Java
myString.Length; //C#
length($my_string) #Perl
```
- Size of List

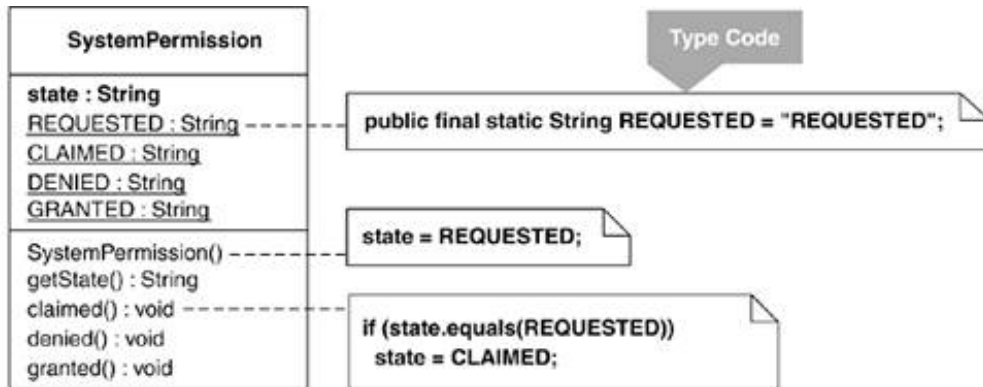
```
myList.size(); //Java
myList.Count; //C#
scalar(@my_list) #Perl
```

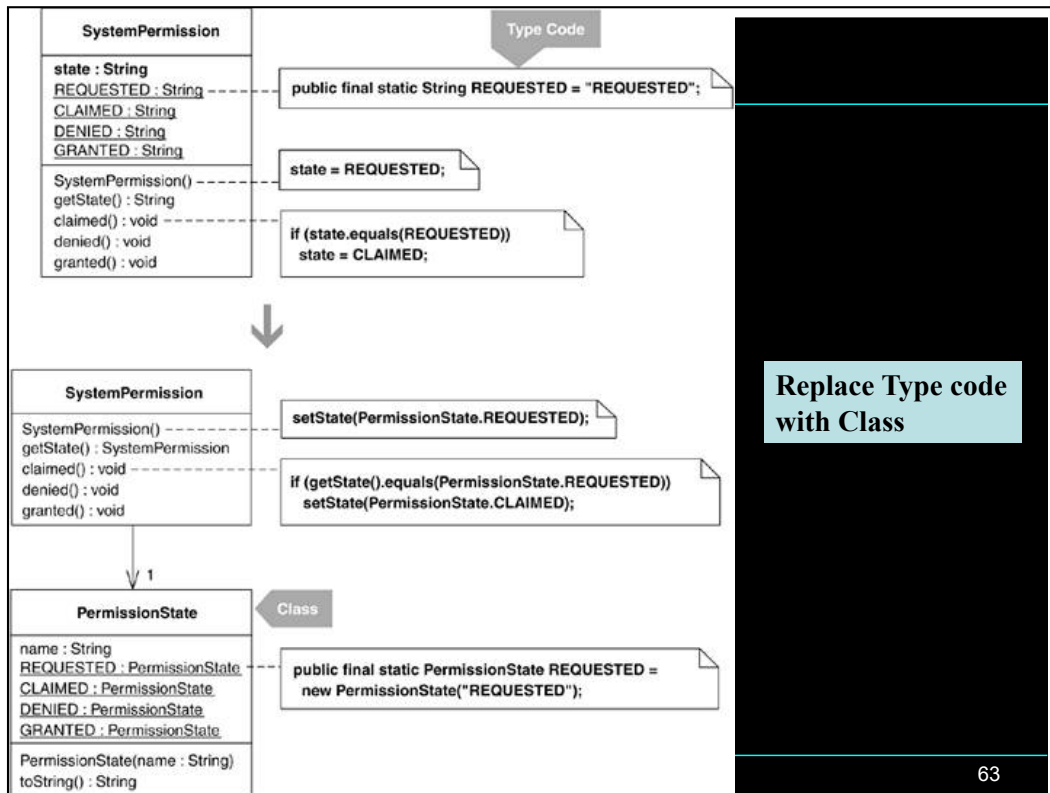


# PHP String Library

- `str_repeat`
- `strcmp`
- `str_split`
- `strlen`
- `str_word_count`
- `strrev`

# Improve Code





A field's type (e.g., a `String` or `int`) fails to protect it from unsafe assignments and invalid equality comparisons.

Constrain the assignments and equality comparisons by making the type of the field a class.

## Benefits and Liabilities

- + Provides better protection from invalid assignments and comparisons.
- Requires more code than using unsafe type does.

## Guideline

- Don't return String that the client has to parse
- Method overloading ???

- Bad: TreeSet is sorted in the 2<sup>nd</sup> case

```
public TreeSet (Collection c);
```

```
public TreeSet (SortedSet s);
```

SortedSet extends Collection!

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Return of sting with multiple values is bad because

Future modifications will become difficult

Bad: In Java, printStackTrace of Throwable class

=====

Overloading - Avoid same name for multiple methods with same number of arguments

In C# and C++, operator overloading should be used only when it is clear. It should not be very frequent.

# Compare

## JUnit3

```
public static Test
suite() {
    Test r = new
        TestSuite();
    //...
    return r;
}
```

## JUnit 4

```
@RunWith(Suite.class)
@TestClasses({
    //List of classes
});
class AllTests {
}
```

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The code on the right

- Is flexible because any runner can be used
- Less prone to error, because the caller does not have to worry about exceptions

## Improve

```
Collection<String> keys =  
    new ArrayList<String>();  
keys.add(key1);  
keys.add(key2);  
object.index(keys);
```

- Use varargs

```
object.index(key1, key2);
```

## Compare

```
static int min(  
    int ... args) {  
    if (args.length  
        <= 0) {  
        //Throw  
        //exception  
    }  
    //Compute Minimum  
}
```

```
static int min(  
    int firstarg,  
    int ... args) {  
    //Compute Minimum  
}
```

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The code on the right

- Is flexible because any runner can be used
- Less prone to error, because the caller does not have to worry about exceptions

In C#, the syntax is

```
static int min(int firstarg, params int[] args)
```

# Java Date and Time

```
Date date =  
    new Date(2007,12,13,16,40);  
TimeZone zone = TimeZone.getTimeZone  
    ("Europe/Bruxelles");  
Calendar cal = new  
    GregorianCalendar (zone);  
cal.setTime(date);  
DateFormat fm = new SimpleDateFormat  
    ("HH:mm Z");  
String str = fm.format(cal);
```

Identify the bugs

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Bug 1: Year should be 107, since base is 1900.

Bug 2: Month should be 11 instead of 12. Since Jan is 0.

Bug 3: "Europe/Bruxelles". Bruzelles is capital of Brussels. It is capital of Belgium. Different people pronounce it different ways. Java returns GMT.

Bug 4: We are creating cal object with invalid or wrong value of date.

Not sure - Bug 5: fm.format gives runtime exception because it cannot format calendar. It can format only dates. So we need to call "cal.getTime()" and pass the returned date to "fm.format"

Not sure - Bug 6: We have not set the timezone in DateFormat. It needs to be set before calling format.



## Problems in Java API

- `java.util.Date`, `java.util.Calendar`, `java.util.DateFormat` are mutable
- Jan is 0, Dec is 11
- `Date` is not a date
- `Calendar` cannot be formatted
- `DateFormat` is not threadsafe
- `java.util.Date` is base for `java.sql.Date` and `java.sql.Time`



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Q53 – Piano

Q73 – Student, Teacher

-----  
Date is not a date because: It has time & It uses from 1900

`java.util.Date` should not be base class for `java.sql.Date` and `Time` because `getYear` on `java.sql.Time` throws an illegal argument exception.

# Principle of Least Astonishment

- User of API should not be surprised by behavior
  - interrupted method in Thread class clears interrupted flag!



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It should have been called `clearInterruptedFlag`

## Find the flaw

```
public boolean checkPassword(  
    String userName, String password) {  
    User user = UserGateway.findByName(userName);  
    if (user != User.NULL) {  
        String codedPhrase =  
            user.getPhraseEncodedByPassword();  
        String phrase = cryptographer.decrypt(  
            codedPhrase, password);  
        if ("Valid Password".equals(phrase)) {  
            Session.initialize();  
            return true;  
        }  
    }  
    return false;}}
```

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This function uses a standard algorithm to match a userName to a password. It returns true if they match and false if anything goes wrong. But it also has a side effect. Can you spot it?

The side effect is the call to `Session.initialize()`, of course. The `checkPassword` function, by its name, says that it checks the password. The name does not imply that it initializes the session. So a caller who believes what the name of the function says runs the risk of erasing the existing session data when he or she decides to check the validity of the user.

This side effect creates a temporal coupling. That is, `checkPassword` can only be called at certain times (in other words, when it is safe to initialize the session). If it is called out of order, session data may be inadvertently lost. Temporal couplings are confusing, especially when hidden as a side effect. If you must have a temporal coupling, you should make it clear in the name of the function. In this case we might rename the function `checkPasswordAndInitializeSession`, though that certainly violates "Do one thing."

## Guidelines

- Keep the command and queries segregated

- Accessors, mutators, and predicates should be named for their value and prefixed with get, set, and is according to the standard.

```
String name =  
    employee.getName() ;  
customer.setName("mike") ;  
if (paycheck.isPosted())...
```

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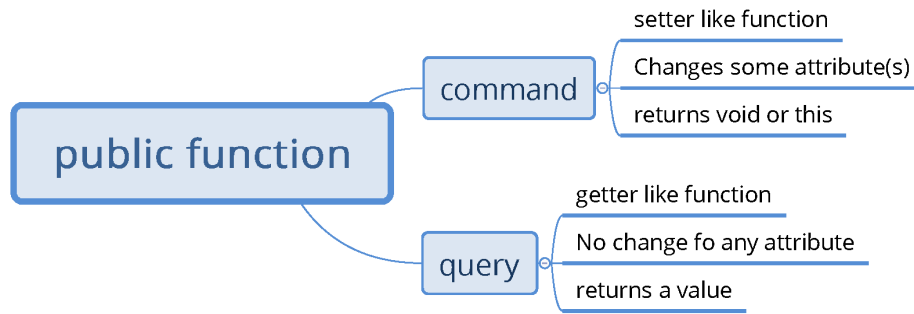
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Exception: DSL.

Commands : return void.

# Command vs Query



## Law of Demeter violated

```
//DOM code to write an XML document to a specified
//output stream
static final void writeDoc(Document doc,
    OutputStream out) throws IOException {
    try {
        Transformer t = TransformerFactory.
            newInstance().newTransformer();
        t.setOutputProperty(OutputKeys.DOCTYPE_SYSTEM,
            doc.getDoctype(), getSystemId());
        t.transform(new DOMSource(doc), new
            StreamResult(out));
    } catch (TransformerException e) {
        throw new AssertionError(e); //can't happen
    }
}
```

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Principle of least knowledge or Law of Demeter:

Each unit should only talk to its friends; Don't talk to strangers.

Don't make the client do anything, that the Module could do

- Reduce the need for boilerplate code

- Generally done via cut-and-paste

- Ugly, Annoying and error-prone

## Reduce Coupling

```
public float getTemp() {  
    return  
    station.getThermometer().getTemp();  
}
```

Vs.

```
public float getTemp() {  
    return station.getTemp();  
}
```

## Where is Law of Demeter violated?

```
public void process(Order o) {  
1)  Message msg = o.getMessage();  
2)  msg.normalize();  
3)  o.getMessage().normalize();  
4)  Instrument symbol =  
        new Instrument();  
5)  symbol.populate();  
}
```

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Answer) lines 2 and 3



# Rule

- Use only one dot per line

Exception: Calling the library functions and DSLs



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Q26Demeter.

## Tell, Don't Ask

- Ask for help, not information



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Never ask an object for information that you need to do something; rather, ask the object that has the information to do the work for you.

In other words: Don't use any getters/setters/properties.

# Avoid getters and setters

- Wrong

```
Money a, b, c;  
//...  
a.setValue( a.getValue() +  
            b.getValue() );
```

- Right

```
Money a, b, c;  
//...  
a.increaseBy( b );
```

# Improve

```
if (aCargo.getStatus() ==  
    HandlingStatus.MISDIRECTED)  
    ...  
  
if (aCargo.isMisdirected())  
    ...
```

# Compare

```
Dog dog = new Dog();  
dog.setBall(  
    new Ball());  
Ball ball =  
    dog.getBall();
```

```
Dog dog = new Dog();  
Dog.setWeight("23Kg");
```

```
Dog dog = new Dog();  
dog.take(new Ball());  
Ball ball =  
    dog.give();
```

```
Dog dog =  
    new Dog("23Kg");
```

## Example

Wrong:

```
MyThing[] things =  
    thingManager.getThingList();  
for (int i = 0; i < things.length; i++) {  
    MyThing thing = things[i];  
    if (thing.getName().equals(thingName))  
        return thingManager.delete(thing);  
}
```

Right:

```
return thingManager.deleteThingNamed  
    (thingName);
```

# Fail-Fast

- Compile time checking is best

Contrast this signature:

```
void assignCustomerToSalesman (  
    long customerId,  
    long salesmanId);
```

with

```
void assignCustomerToSalesman (  
    Customer c,  
    Salesman s);
```

## Fail Fast

- Bad:  
In Java a Properties class maps String to String

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put method does not make this check  
save method does this check



# Compare

```
void setAmount(int
  value, String
  currency) {
    this.value =
        value;
    this.currency =
        currency;
}
```

```
void setAmount(
    Money value) {
    this.value=value;
}
```

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The code on the right

- Is flexible because any runner can be used
- Less prone to error, because the caller does not have to worry about exceptions

## Improve

```
setOuterBounds ( x, y,  
                width, height);  
setInnerBounds ( x+2, y+2,  
                width-4, height-4);
```

- Solution: Use Parameter Object

```
setOuterBounds (bounds);  
setInnerBounds (bounds.expand  
                (-2));
```

## Guideline

- Wrap all primitives and Strings

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An int on its own is just a scalar with no meaning. When a method takes an int as a parameter, the method name needs to do all the work of expressing the intent. If the same method takes an hour as a parameter, it's much easier to see what's happening. Small objects like this can make programs more maintainable, since it isn't possible to pass a year to a method that takes an hour parameter. With a primitive variable, the compiler can't help you write semantically correct programs. With an object, even a small one, you are giving both the compiler and the programmer additional information about what the value is and why it is being used. Small objects such as hour or money also give you an obvious place to put behavior that otherwise would have been littered around other classes. This becomes especially true when you apply the rule relating to getters and setters and only the small object can access the value.

## Direct access to Variables

- Compare

`doorRegister=1;`

with

`openDoor ();`

with

`door.open ();`

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The last one is the best. It uses objects and functions.

# Single Responsibility Principle

- A class should have only one reason to change.

- Bad

```
public class Employee {  
    public double calculatePay();  
    public double calculateTaxes();  
    public void writeToDisk();  
    public void readFromDisk();  
    public String createXML();  
    public void parseXML(String xml);  
    public void displayOnEmployeeReport(  
        PrintStream stream);  
    public void displayOnPayrollReport(  
        PrintStream stream);  
    public void displayOnTaxReport(  
        PrintStream stream);  
}
```

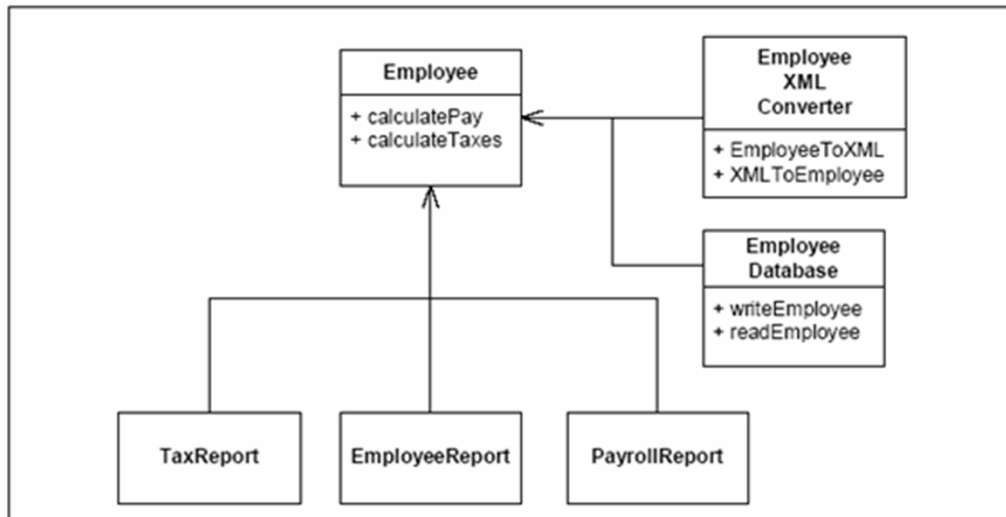
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An item such as a class should just have one responsibility and solve that responsibility well. If a class is responsible both for presentation and data access, that's a good example of a class breaking SRP.

# SRP implemented



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# Popular API

- Java
  - `java.xml.datatype.XMLGregorianCalendar` has both date and time
  - `java.util.concurrent.TimeUnit` is an enum for various units and also converts from one form to another.
- C#
  - `DateTime`



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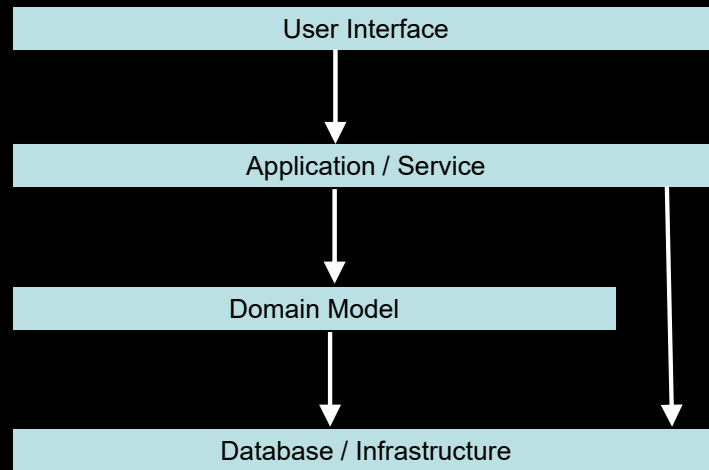
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Q50 – Account

Q51 – Department

Q55 – processReport1

# SRP in Architecture - Layering



Layering can be at function / class / package level

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Service / Application layer co-ordinates tasks and delegates work to the domain. In an rich domain model, Service layer should be as thin as possible.

Interactions with the legacy systems is at Infrastructure level.

Usually the service layer

1. Gets the Database objects by interacting directly with Database layer and then
2. The domain model is executed in the objects.

In Java EE 1.4 or less,

Session beans are at service layer

Entity beans are at Database layer.

If business logic code is kept in Session beans, then it will become transaction script.

If business logic code is kept in Entity beans, then it will become Table Module

Table module is popular in .NET. Transaction script was popular with VB6.



One of the hardest parts of working with domain logic seems to be that people often find it difficult to recognize what is domain logic and what is other forms of logic. An informal test I like is to imagine adding a radically different layer to an application, such as a command-line interface to a Web application. If there's any functionality you have to duplicate in order to do this, that's a sign of where domain logic has leaked into the presentation. Similarly, do you have to duplicate logic to replace a relational database with an XML file?

## Interface Segregation Principle

- Interfaces should be as fine-grained as possible.

- Any problem:

```
public interface Modem {  
    public void dial(String pno);  
    public void hangup();  
    public void send(Char c);  
    public char recv();  
}
```

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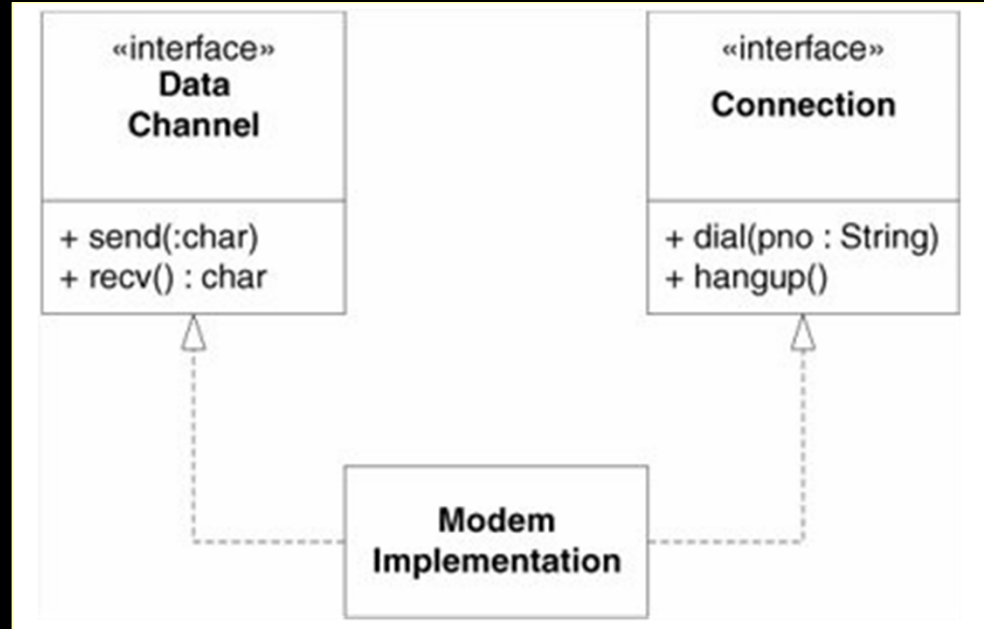
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Clients should not be forced to depend upon the interfaces that they do not use. – Robert Martin

If a class implements an interface with multiple methods, but in one of the methods throws `NotSupportedException`, then this principle is violated.

# ISP implemented

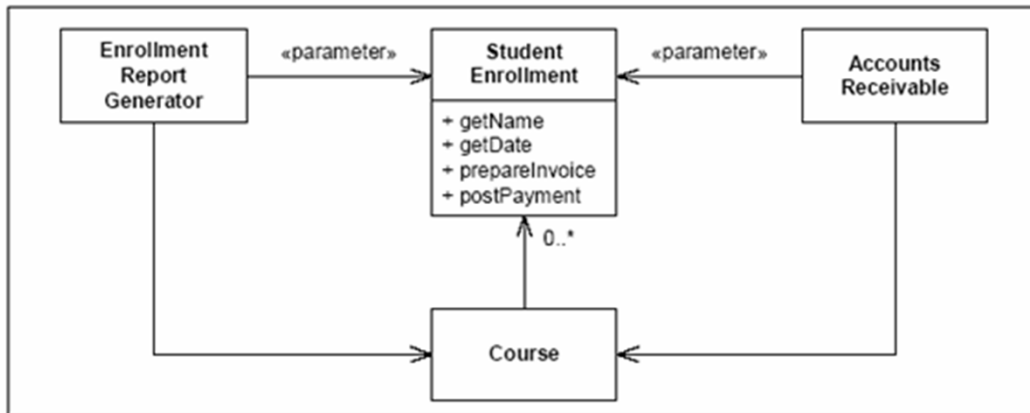


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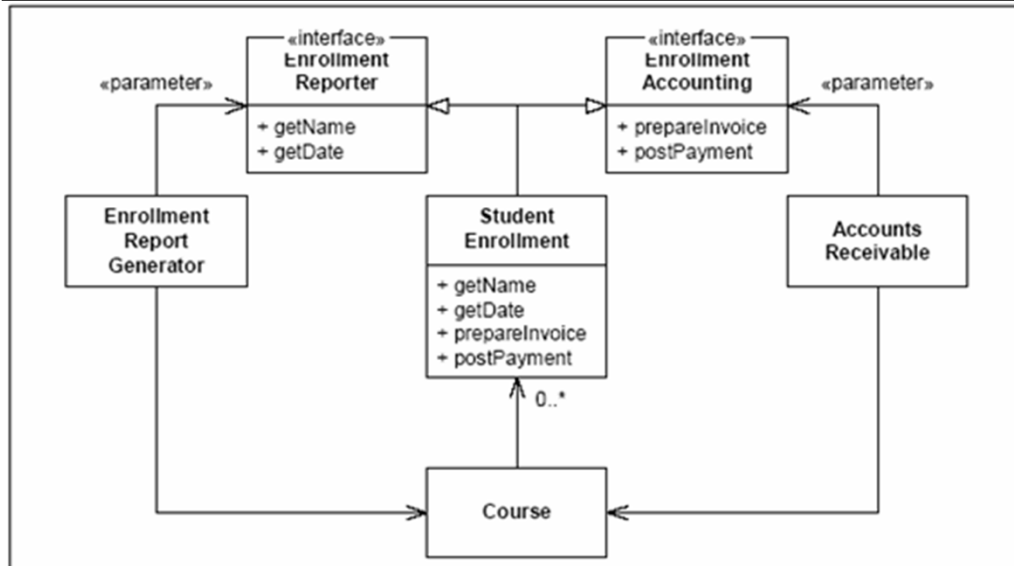
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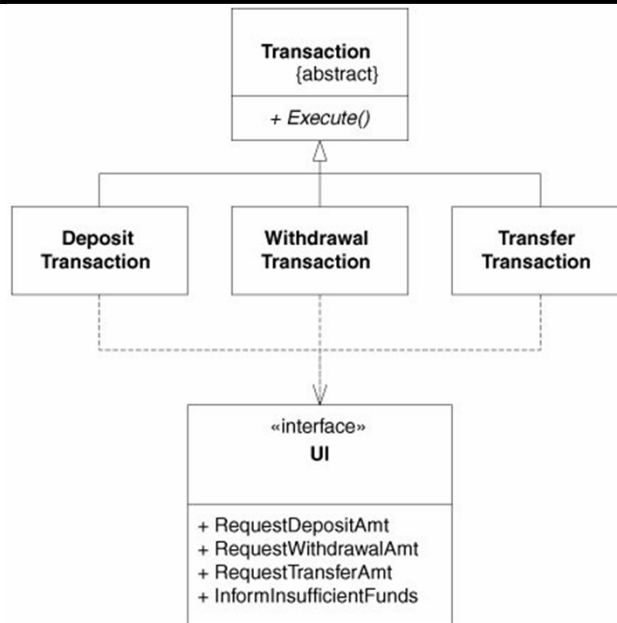
# ISP violated



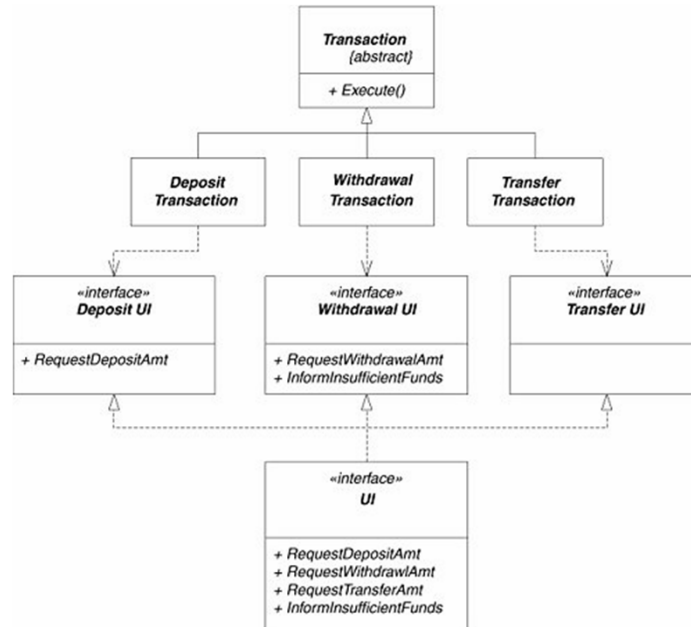
# ISP implemented



# ISP violated



# ISP implemented



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## Open Closed Principle

- Software entities (Classes, modules, functions) should be open for extension but closed for modifications.

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It should be possible to change the environment of a class without changing the class.

A class should be closed for modification, but open for extension. When you change a class, there is always a risk that you will break something. But if instead of modifying the class you extend it with a sub-class, that's a less risky change.



## Guidelines

- Keep things that vary separately from things that are common.



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Q45 – LoanHandler

Q44 – FILE1, DATABASE1

Q39 - Scheduler

Q83 – Cooker

Q84 – ChooseFontDialog

# Dependency Inversion Principle

- Program to an interface and not to an implementation
  - Any problem?



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“HIGH LEVEL MODULES SHOULD NOT DEPEND UPON LOW LEVEL MODULES, BOTH SHOULD DEPEND UPON ABSTRACTIONS.

ABSTRACTIONS SHOULD NOT DEPEND UPON DETAILS. DETAILS SHOULD DEPEND UPON ABSTRACTIONS.”

No variable should hold a reference to a concrete class.

No class should derive from a concrete class.

No method should override an implemented method of any of its base classes.

It is OK to depend on stable classes like String, Integer, JPanel, etc.

Avoids designs that are rigid, Fragile and Immobile.

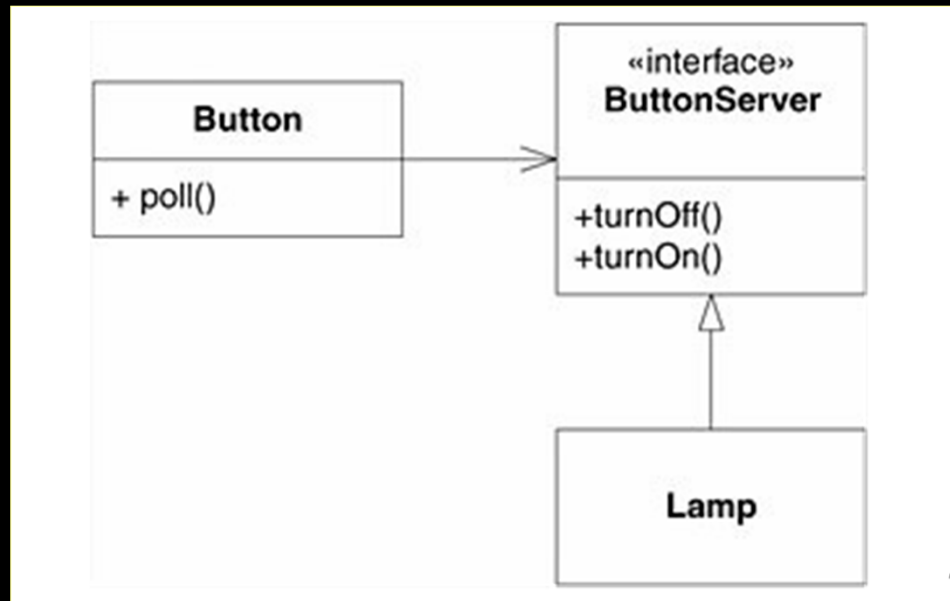
Example: We have a classes: Copy, Keyboard, Printer. The Copy reads from keyboard and prints to the printer. If we use DIP, we have an abstraction for Keyboard and Printer. So we can add input and output devices later on.

Example: Collections in Java.

Example: Customer is a class. Employee is a class. Employees are now allowed to purchase on credit. We need an interface Buyer.

For every variable use the maximum abstract type possible.

## DIP implemented



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### Advantages

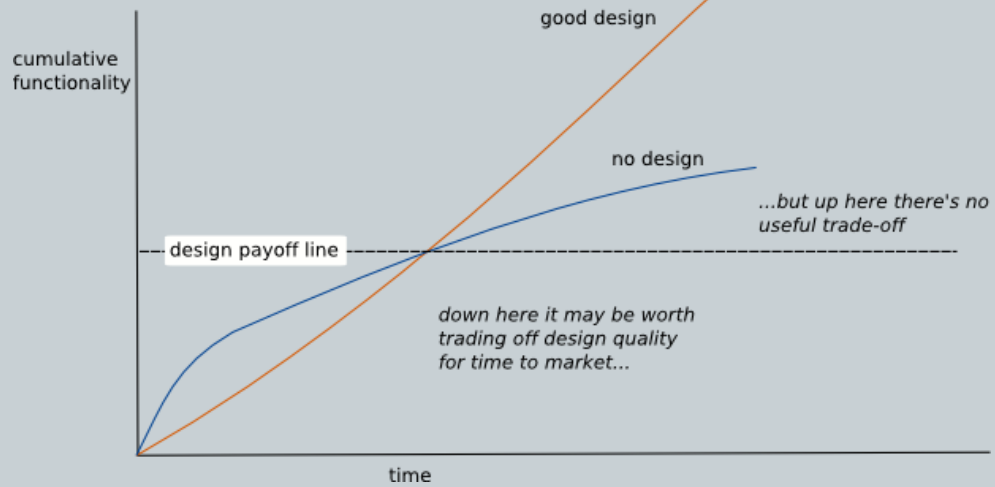
- Clients are unaware of the specific class of the object they are using
- One object can be easily replaced by another
- Object connections need not be hardwired to an object of a specific class, thereby increasing flexibility
- Loosens coupling
- Increases likelihood of reuse
- Improves opportunities for composition since contained objects can be of any class that implements a specific interface

### Disadvantages

- Modest increase in design complexity

Q96, Q94, Q93, Q91 - DIP

# Is Good Design worth it?



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## Let us be Practical

- Not all of a large system will be well designed.
- Our application has
  - Generic Subdomain
  - Supporting Subdomain
  - Core Domain

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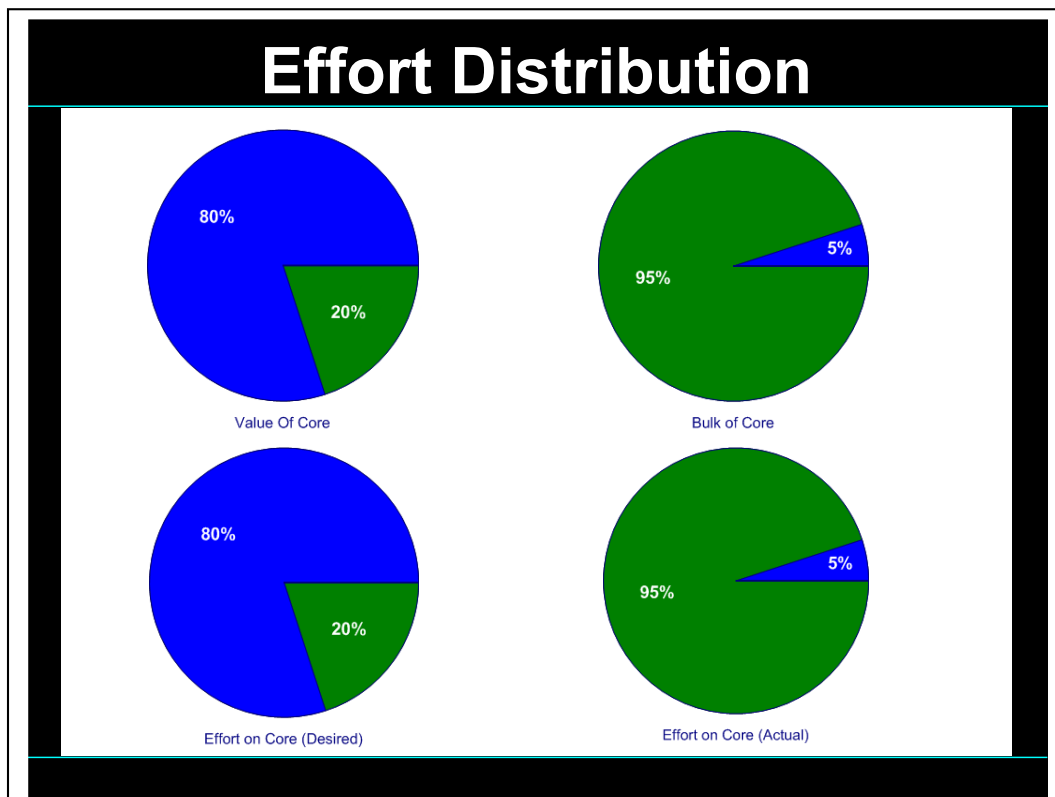
Core domain:

The core domain is the one with business value, the one that makes your business unique. Apply your best talent to the core domain. Spend a lot of time on it and make it as good as you can.

Generic Subdomain: Identify cohesive subdomains that are not the motivation for your project. Factor out generic models of these subdomains and place them in separate modules. These domains are not as important as the core domains. Don't assign your best developers to them. Consider off-the-shelf solutions or a published model. E.g. calendar, Invoicing, Accounting

Supporting Subdomain: Related to our domain but not worth spending millions of dollars every year. E.g. Advt's on bank statements.

User ratings on Amazon and Ebay. On Amazon, this feature is supporting domain because customers usually buy the book even if others have given it low rating and they really want it. For ebay it is core domain because people will hesitate to make a deal with a person with low rating.



From Domain Driven Design.

## Domain Vision Statement

- Write a short description (about one page) of the core domain and the value it will bring.
- Ignore aspects that are the same as other domain models.
- Write this statement early and revise it as you gain new insight.

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Highlighted Core: Write a very brief document (3-7 pages) that describes the core domain and the primary interactions between core elements.

# Design Smells

- Duplication
- Long Method
- Large Class
- Long Parameter List
- Divergent Change
- Shotgun Surgery
- Feature Envy
- Primitive Obsession
- Switch statements
- Parallel Inheritance Hierarchy
- Lazy class
- Speculative Generality
- Data Class
- Refused Bequest
- Comments
- Data Clumps

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Divergent change occurs when one class is commonly changed in different ways for different reasons. If you look at a class and say, "Well, I will have to change these three methods every time I get a new database; I have to change these four methods every time there is a new financial instrument," you likely have a situation in which two objects are better than one. That way each object is changed only as a result of one kind of change.

Shotgun surgery is similar to divergent change but is the opposite. You whiff this when every time you make a kind of change, you have to make a lot of little changes to a lot of different classes. When the changes are all over the place, they are hard to find, and it's easy to miss an important change.

Feature Envy: The whole point of objects is that they are a technique to package data with the processes used on that data. A classic smell is a method that seems more interested in a class other than the one it actually is in.

Data Clumps: Data items tend to be like children; they enjoy hanging around in groups together. Often you'll see the same three or four data items together in lots of places: fields in a couple of classes, parameters in many method signatures. Bunches of data that hang around together really ought to be made into their own object.

Data classes are like children. They are okay as a starting point, but to participate as a grownup object, they need to take some responsibility.

**Refused Bequest:** Subclasses get to inherit the methods and data of their parents. But what if they don't want or need what they are given? They are given all these great gifts and pick just a few to play with.



## Summary

- Keep it DRY, shy and tell the other guy.
- Prefer delegation over inheritance
- Self-documenting code
- Not all parts of a large system will be well-designed.

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No Golden Bullet.