CSE 4513

Lec – 8

Software Design

Bad Design Risk

- **103-year-old man asked to bring parents for eye test (Aug 22, 2002)**

– British pensioner Joseph Dickinson, 103Yrs, had a shock when his local hospital called him in for an eye test and told him to bring his parents.

– "I must be getting younger, in fact much younger," he told his local paper, the Hartlepool Mail. He was born in 1899.

– because the hospital computer only read the last two digits it mistook his age as just three years (**103**) old....

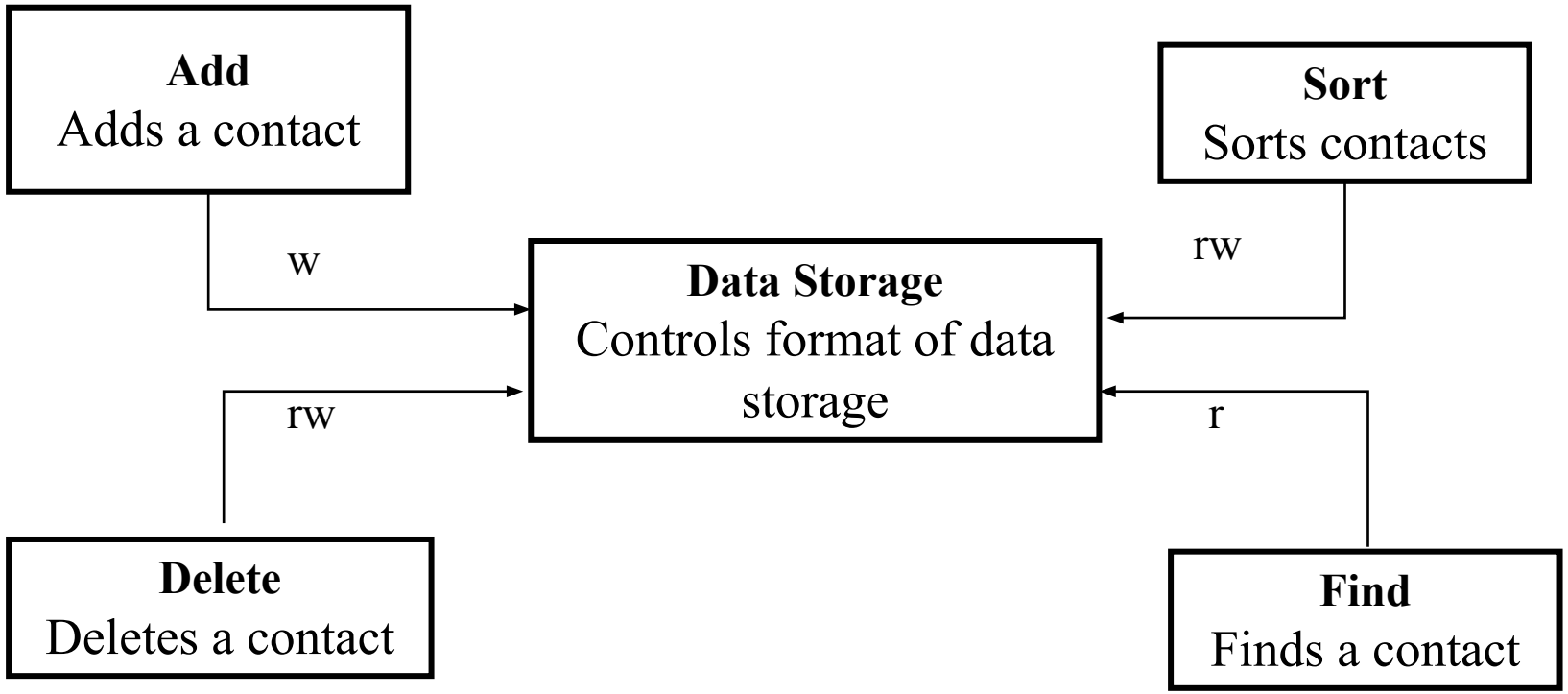
Historic Context

- 1960s
  - Structured Programming
- 1970s
  - Structured Design
    - Methodology/guidelines for dividing programs into subroutines.
- 1980s
  - Modular (object-based) programming
- 1990s
  - Object-Oriented Languages started being commonly used
  - Object-Oriented Analysis and Design for guidance

We are mainly interested in modular design

Design Example – Address book

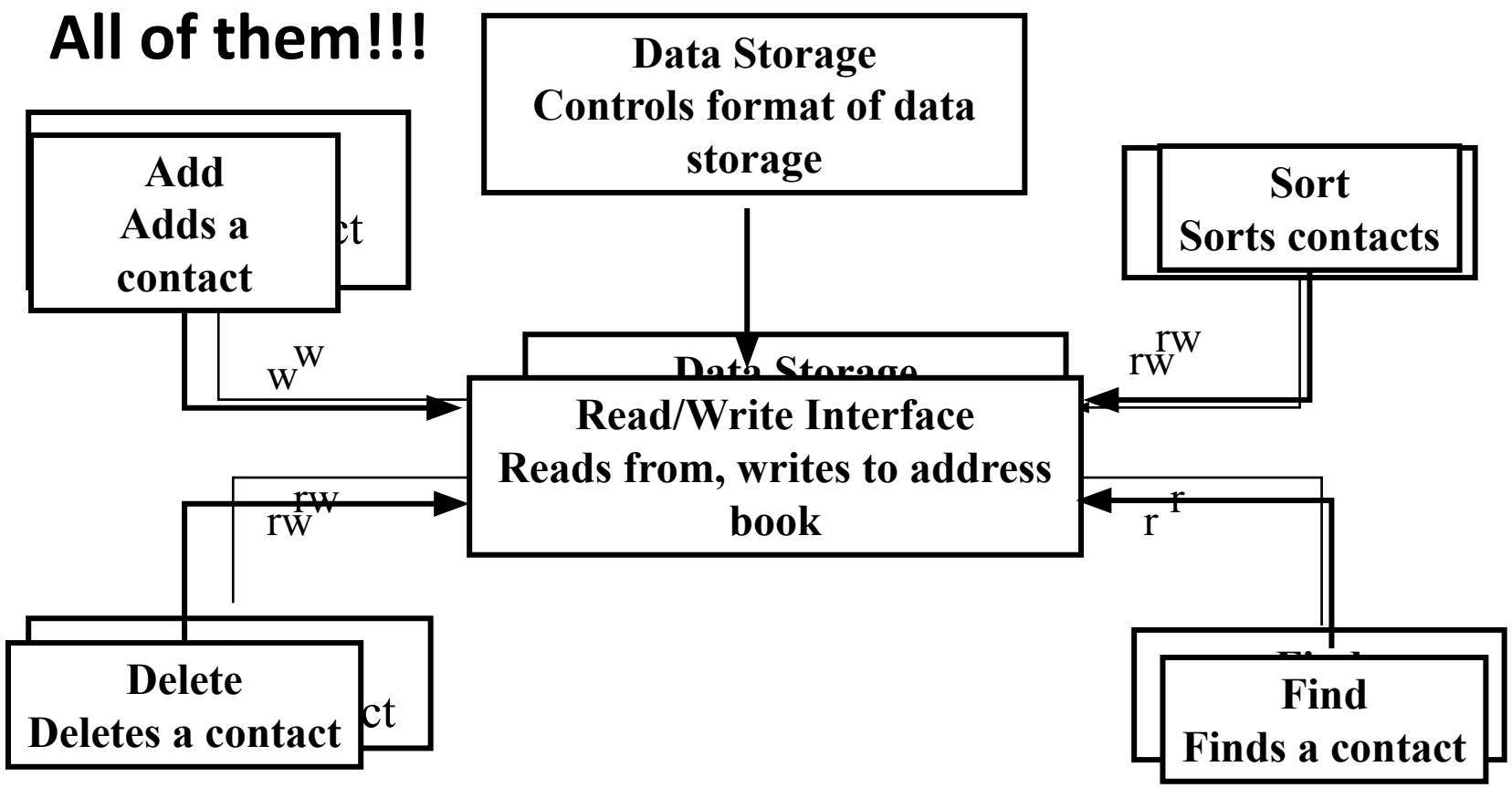
- Contacts are stored in a plain text file
- They are stored in the following syntax ***First Name Last name, address line 1, address line 2***
- All contacts are separated by a semi-colon



Design Example – Address book

- But what if we would like to change the format of data storage to - [First Name Last name | address line 1| address line 2]

What modules will we need to modify?



In this design, the new change would only require modifying the **Data Storage** and the **Read/Write Interface** modules.

The **Add**, **Delete**, **Sort** and **Find** modules do not need any changes. Their algorithms remain untouched.

Can you figure out Any advantage?

If you want to explore more

https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.38.3667&rep=rep1&type=pdf

The Modular Structure of Complex Systems

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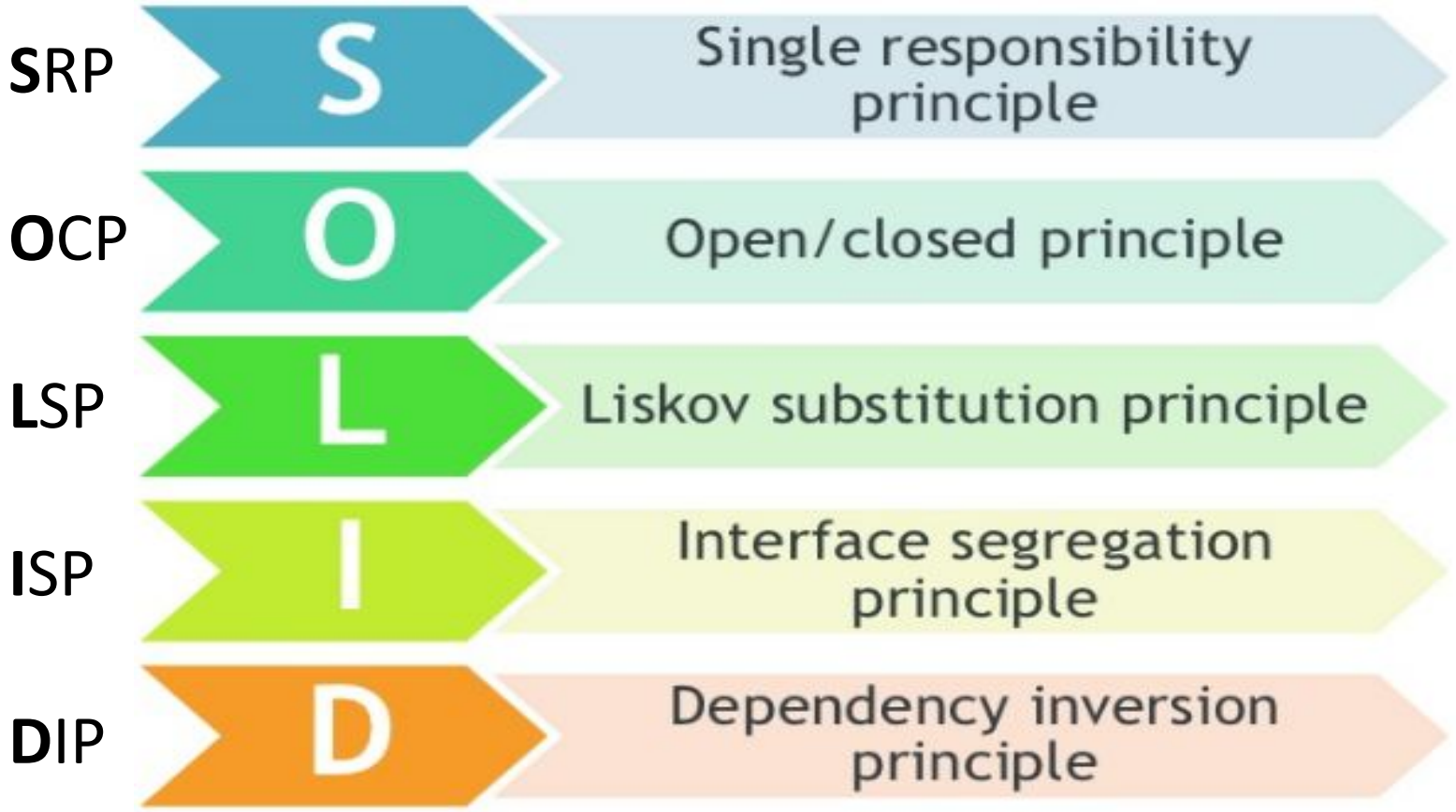
SOLID Again

S.O.L.I.D. Principles



SRP: The Single Responsibility Principle

Every object should have a single responsibility, and that responsibility should be entirely encapsulated by the class. ~Wikipedia

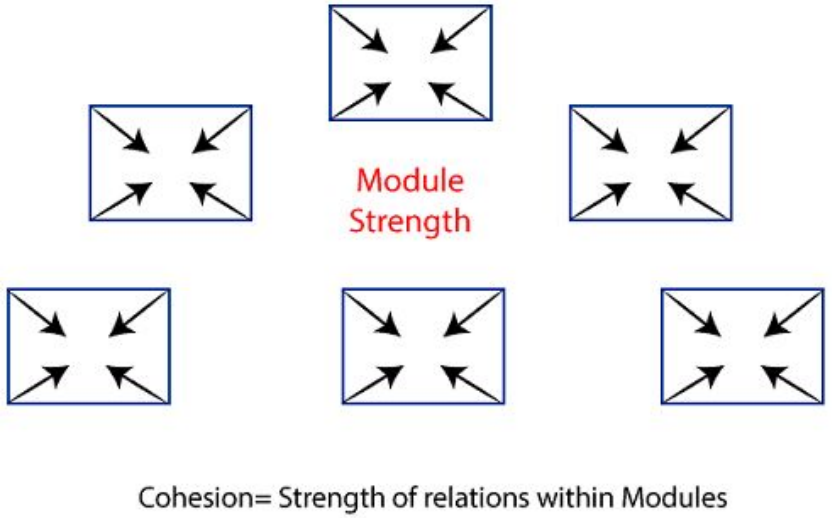
There should never be more than one reason for a class to change.

~Robert C. “Uncle Bob” Martin

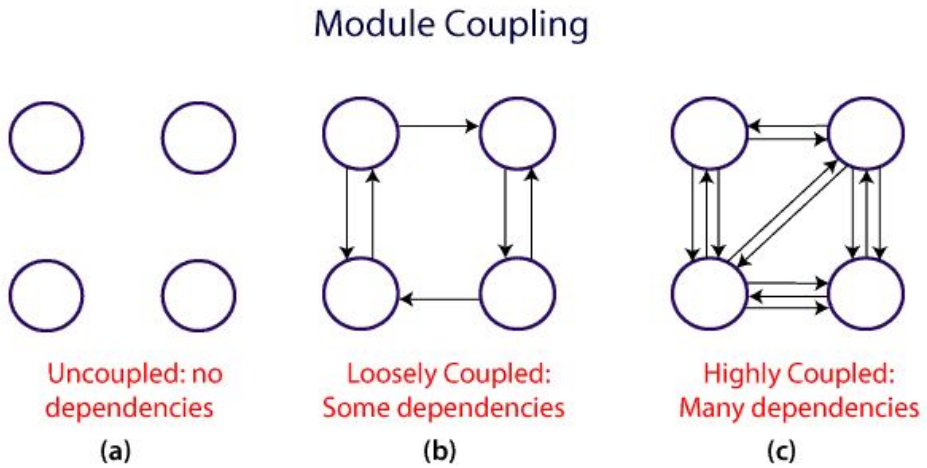
A module should have one, and only one, reason to change.

Cohesion and Coupling

- ✔ **Cohesion:** how strongly-related and focused are the various responsibilities of a module
- ✔ A measure of how closely related the members (classes, methods, etc..) of a module are to the other members of the same module. It is desirable to **increase cohesion** as that indicates that a module has a very specific task and does only that task.
- ✔ **Coupling:** the degree to which each program module relies on each one of the other modules
- ✔ A measure of how much a module (package, class, method) relies on other modules. It is desirable to **reduce coupling**, or reduce the amount that a given odules of a system



Cohesion= Strength of relations within Modules



Strive for low coupling and high cohesion!

Cohesion and Coupling

Reading assignment

https://prl.ccs.neu.edu/img/p-tr-1971.pdf

Carnegie Mellon University
Research Showcase @ CMU

Computer Science Department | School of Computer Science

1971

On the criteria to be used in decomposing systems into modules

David Lorge. Parnas
Carnegie Mellon University

What is a Responsibility?

✔ “a reason to change”

✔ A difference in usage scenarios from the client’s perspective

Responsibilities are Axes of Change

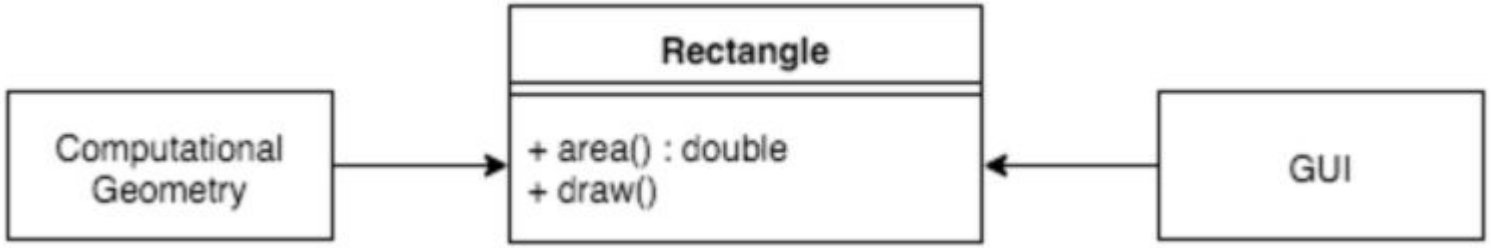
- ✔ Requirements changes typically map to responsibilities
- ✔ More responsibilities == More likelihood of change
- ✔ Having multiple responsibilities within a class couples together these responsibilities

The more classes a change affects, the more likely the change will introduce errors.

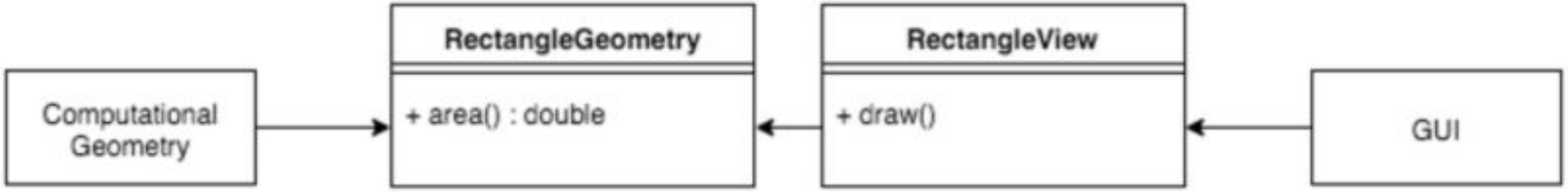
SRP: The Single Responsibility Principle

- ✔ each class should have **one responsibility**, one **single purpose**.
- ✔ This means that a class will do only one job, which leads us to conclude it should have only **one reason to change**.
- ✔ if we have a class that we change a lot, and for different reasons, then this class should be broken down into more classes, each handling a single concern. Surely, if an error occurs, it will be easier to find.

SRP Example



- ✔ Here , a rectangle class that has two methods; Area () & Draw ().
  - Area () has the responsibility to return the area of a rectangle
  - Draw () has the responsibility to draw the rectangle itself
- ✔ if there are changes in the GUI, we must modify the Rectangle class,
- ✔ divide the class in two, so that each class has a unique responsibility.



Now, One will be responsible for calculating and another one for painting.

More Example

Consider a class for trading application that buys and sells. And we implement a class, named **Transaction** , has two responsibilities: ***buying*** and ***selling***.

```
// Class to handle both Buy and Sell actions
class Transaction {
    // Method to Buy, implemented in Transaction class
    private void Buy(String stock, int quantity, float price){
        // Buy stock functinality implemented here
    }
    // Method to Sell, implemented in Transaction class
    private void Sell(String stock, int quantity, float price){
    // Sell stock functionality implemented here
    }
}
```

if the requirements for either method change it would necessitate a change in the **Transaction** class. In other words, **Transaction** has multiple responsibilities.

More Example

Refactoring these methods into separate classes would be one approach to applying the Single Responsibility Principle to this application.

```
class Transaction{
        private void Buy(String stock, int quantity, float price){
                Buy.execute(stock, quantity, price);
        }
        private void Sell(String stock, int quantity, float price){
        Sell.execute(stock, quantity, price);
        }
}
class Buy{
        static void execute(String ticker, int quantity, float price){
        }
}
class Sell{
        static void execute(String ticker, int quantity, float price){
        }
}
```

- ✔ Now, Each of those refactored classes is assigned with a single responsibility.
- ✔ The **Transaction** class can still perform two separate tasks but is no longer responsible for their implementation.

SRP - Summary

- ✔ Following SRP leads to lower coupling and higher cohesion
- ✔ Many small classes with distinct responsibilities result in a more flexible design
- ✔ When we split responsibilities between smaller methods and classes, usually the system becomes easier to learn overall.
- ✔ It becomes possible to reuse components when they have a single, narrow responsibility.
- ✔ Most methods with a narrow responsibility shouldn’t have side effects
- ✔ t’s easier to write and maintain tests for methods and classes with focused, independent concerns
- ✔ Having methods with single responsibilities also helps to quickly pinpoint performance problems
- ✔ the more focused responsibilities of the components we make, the more code we will need to write.
- ✔ it takes more time and effort to develop the first version of the application with finely separated responsibilities than with larger components.

OCP: Open/Closed Principle

- The Open / Closed Principle states that software entities (classes, modules, functions, etc.) should be open for **extension**, but closed for **modification**
- In other words, once a module is developed and working, it should be able to accommodate new functionality **without altering its existing codebase**.

A software artifact should be open for extension but closed for modification.

The Open / Closed Principle

- ✔ Open to Extension
  - New behavior can be added in the future
- ✔ Closed to Modification
  - Changes to source or binary code are not required
- ✔ The "closed" part of the rule states that once a module has been developed and tested, the code should only be changed to correct bugs.
- ✔ The "open" part says that you should be able to extend existing code in order to introduce new functionality.

Dr. Bertrand Meyer originated the OCP term in his 1988 book, Object Oriented Software Construction

The Open / Closed Principle

This approach allows **extended** functionality via concrete implementation classes without necessitating changes to **base classes**. In other words, a developer **can add new functionality without changing the existing code** of related functions, classes, and methods!

OCP Example

Let's say that we've got a Rectan…

Now our customer wants us to buil… a collection of rectangles…

We present our solution, the AreaCalculator class to client and he signs us his praise. But he also wonders if we couldn't extend it so that it could calculate the area of not only rectangles but of circles as well.

That complicates things a bit but after some consideration we come up with a solution where we change our Area… to accept a collection of objects … the more specific Rectangle type.

```
public double Area(object[] shapes)
{
    double area = 0;
    foreach (var shape in shapes)
    {
        if (shape is Rectangle)
        {
            Rectangle rectangle = (Rectangle) shape;
            area += rectangle.Width*rectangle.Height;
        }
        else
        {
            Circle circle = (Circle)shape;
            area += circle.Radius * circle.Radius * Math.PI;
        }
    }

    return area;
}
```

The solution works and client is happy

Only, a week later he calls us and … calculate the area of triangles is … scenario it isn't but it does requ… isn't **closed for modifica…** other words: it isn't **open**…

In a real world scenario w… larger and modifying th… different servers that can…

A solution abides by the Open/Closed Principle

As we've moved the responsibility of actually calculating the area away from AreaCalculator's Area method it is now much simpler and robust as it can handle any type of Shape that we throw at it.

Inheriting from Shape the Rectangle and Circle classes now looks like this:

```
public double Area(Shape[] shapes)
{
    double area = 0;
    foreach (var shape in shapes)
    {
        area += shape.Area();
    }

    return area;
}
```

```
public class Rectangle : Shape
    {
        return Radius*Radius*Math.PI;
    }
}
```

In other words we've closed it for modification by opening it up for extension.

When do we apply OCP?

Experience Tells You

- ✔ If you know from your own experience in the problem domain that a particular class of change is likely to recur, you can apply OCP up front in your design

Otherwise – "Fool me once, shame on you; fool me twice, shame on me"

- ✔ Don't apply OCP at first
- ✔ If the module changes once, accept it.
- ✔ If it changes a second time, refactor to achieve OCP

Remember

- ✔ **OCP adds complexity to design**
- ✔ **No design can be closed against all changes**

LSP: The Liskov Substitution Principle

Child classes should never break the parent class' type definitions.

The concept of this principle was introduced by Barbara Liskov in a 1987

Their original definition is as follows:

Let q(x) be a property provable about objects x of type T. Then q(y) should be provable for objects y of type S where S is a subtype of T.

This leads us to the definition given by Robert C. Martin:

Subtypes must be substitutable for their base types.

SUBSTITUTABILITY

Child classes must not:

1) Remove base class behavior
2) Violate base class invariants

Substitution Principle: If B is a subtype of A, everywhere the code expects an A, a B can be used instead and the program still satisfies its specification

In general, OOP teaches use of IS-A to describe child classes' relationship to base classes

BUT

LSP suggests that IS-A should be replaced with IS-SUBSTITUTABLE-FOR

LET'S DO AN EXAMPLE!

Let's check the below code:

```
class Transportation
{
        String name;
        String getName() { ... }
        void setName(String n) { ... }
        double speed;
        double getSpeed() { ... }
        void setSpeed(double d) { ... }
        Engine engine;
        Engine getEngine() { ... }
        void setEngine(Engine e) { ... }
        void startEngine() { ... }
}
class Car extends Transportation
{
        @Override
        void startEngine() { ... }
}
```

There is no problem here, right? A car is definitely a **transportation**, and here we can see that it overrides the startEngine() method of its superclass.

Let's add another **transportation**:

```
class Bicycle extends Transportation
{
        @Override
        void startEngine() /*problem!*/
}
```

Everything isn't going as planned now!
a bicycle is a transportation , however, it does not have an engine so the method startEngine() cannot be implemented.

LET'S DO AN EXAMPLE!

We can refactor our **Transportation** class as follows:

```
class Trasportation
{
   String name;
   String getName() { ... }
   void setName(String n) { ... }
   double speed;
   double getSpeed() { ... }
   void setSpeed(double d) { ... }
}
```

we can extend Transportation for non-motorized devices.

```
class TransportWithoutEngine extends Transportation
{
        void startMoving() { ... }
}
```

Now we can extend Transportation for motorized devices.

```
class TransportWithEngine extends Transportation
{
   Engine engine;
   Engine getEngine() { ... }
   void setEngine(Engine e) { ... }
   void startEngine() { ... }
}
```

Now,Car class becomes more specialized, while adhering to the Liskov Substitution Principle.

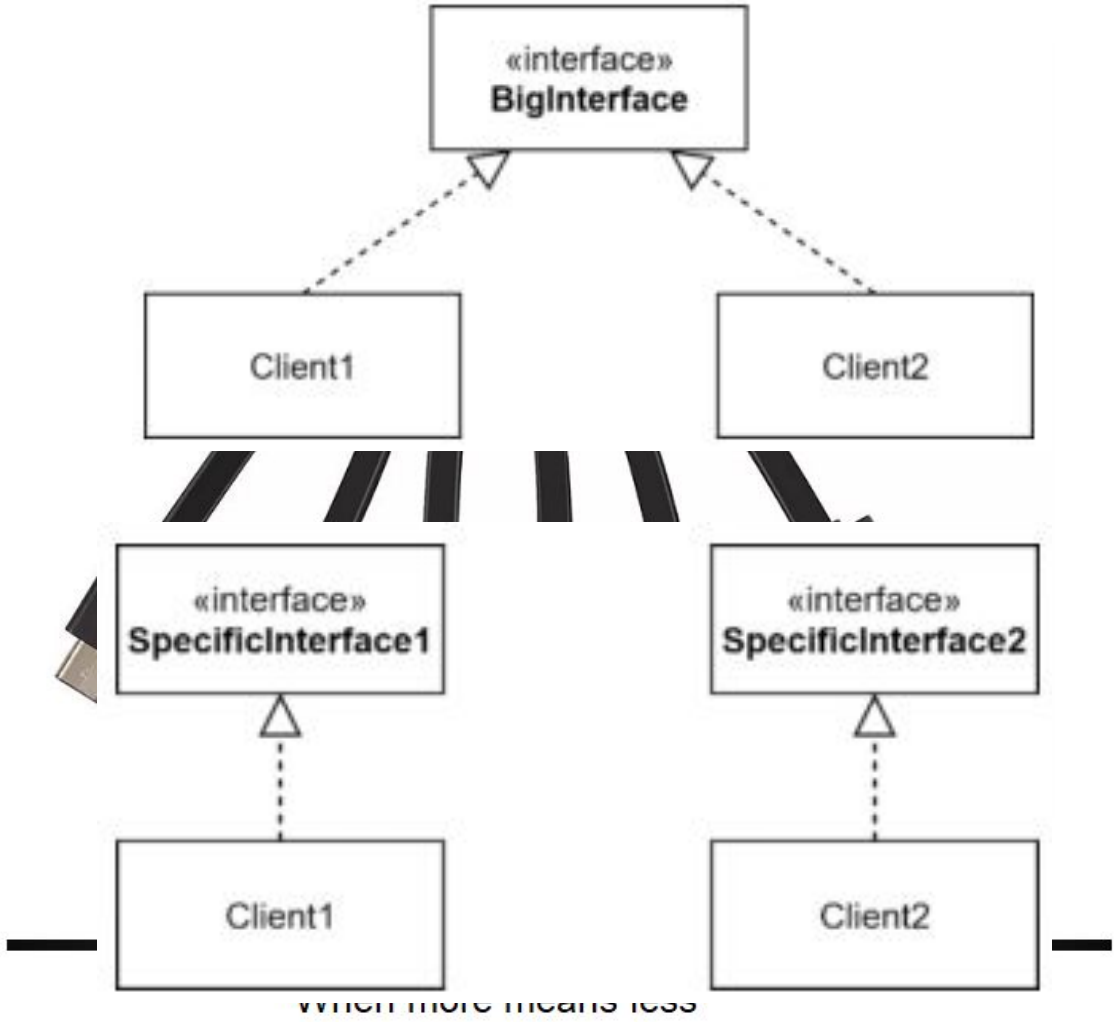
And Bicycle class is also in compliance with the Liskov Substitution Principle.

```
class Bicycle extends TransportWithoutEngine
{
        @Override
        void startMoving() { ... }
}
```

This demonstrates the LSP in action because the derived classes (**TransportWithoutEngine** and **TransportWithEngine**) are substitutable for the base class (**Transportation**) without any issues, and the program behaves correctly.

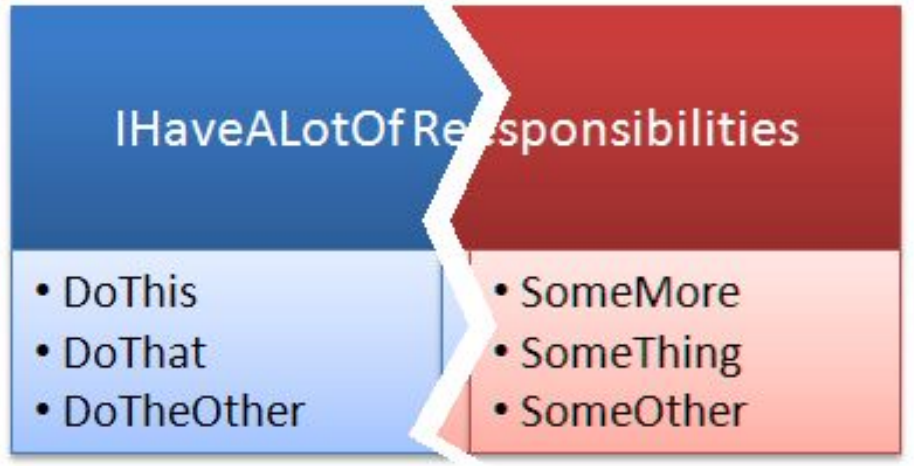
Interface Segregation Principle

- ✔ Clients should not be forced to depend on methods they do not use.
- ✔ This means the methods of an interface can be broken up into multiple groups, where each group serves a different client.
- ✔ In other words, one group is there for one client, while the other group is there for another one.
- ✔ is very much related to the Single Responsibility Principle
- ✔ According to the interface segregation principle, you should break down “fat” interfaces into more granular and specific ones.



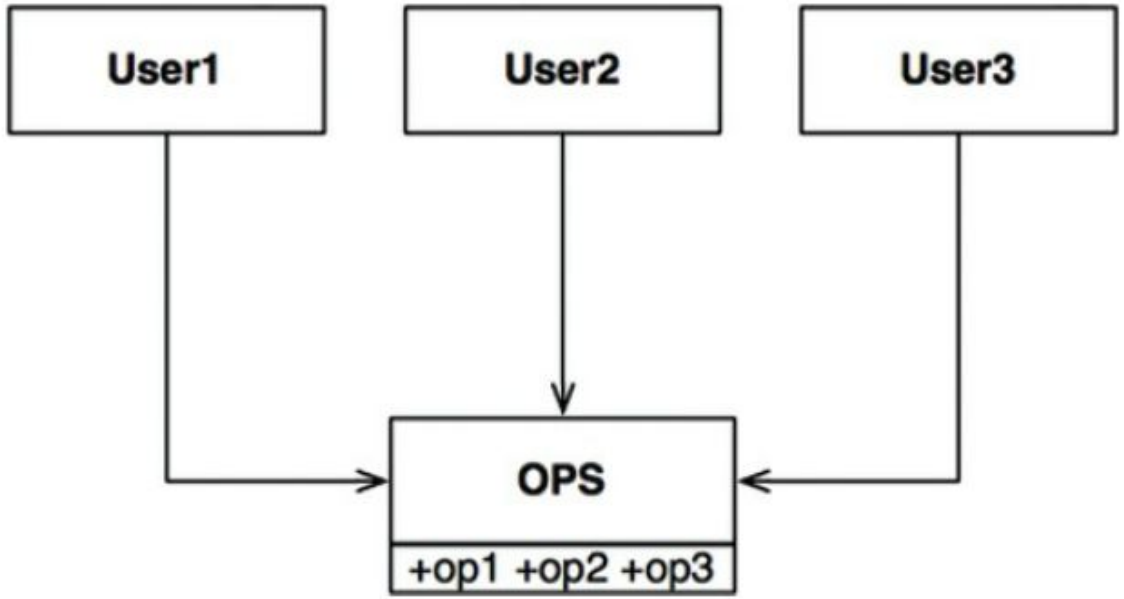
Interface Segregation Principle

"This principle deals with the disadvantages of 'fat' interfaces. Classes that have 'fat' interfaces are classes whose interfaces are not cohesive. In other words, the interfaces of the class can be broken up into groups of member functions. Each group serves a different set of clients. Thus some clients use one group of member functions, and other clients use the other groups."



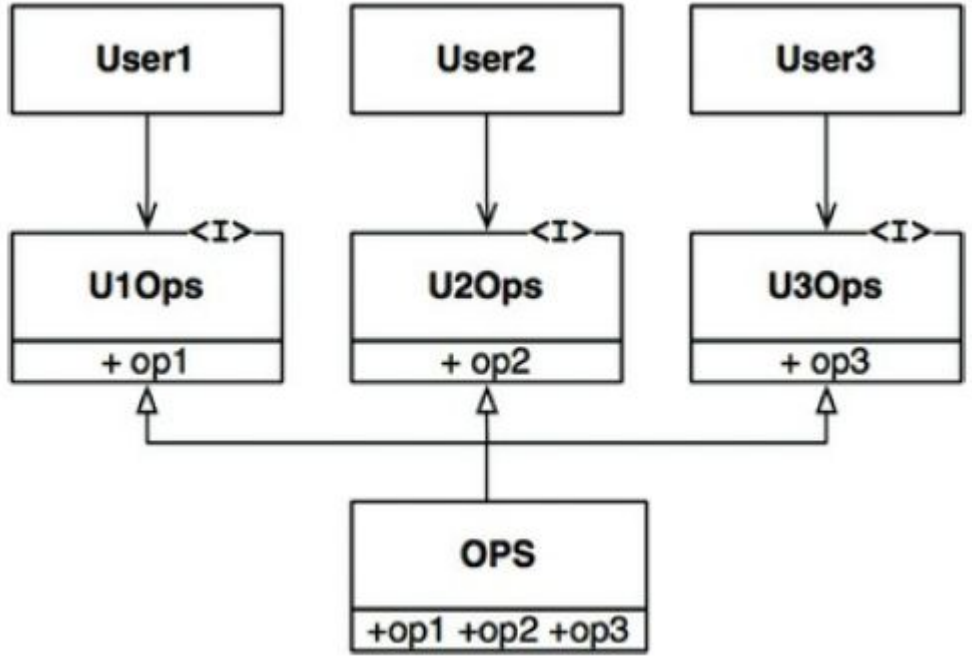
- Robert Martin

Interface Segregation Principle



assume that `User1` uses only `op1`, `User2` uses only `op2`, and `User3` uses only `op3`.

the source code of `User1` will inadvertently depend on `op2` and `op3`, even though it doesn't call them. This dependence means that a change to the source code of `op2` in `OPS` will force `User1` to be recompiled and redeployed, even though nothing that it cared about has actually changed.

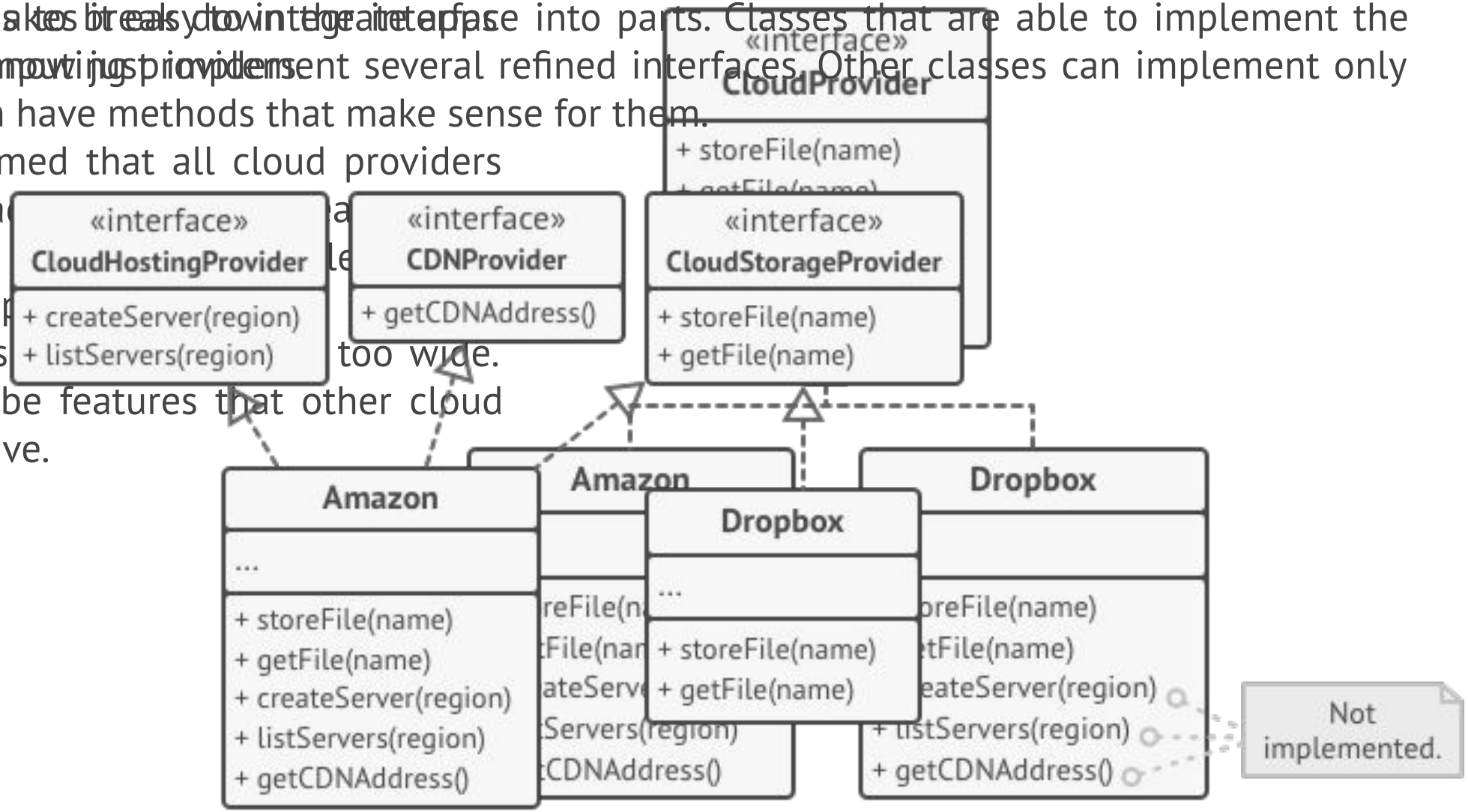


Now the source code of `User1` will depend on `U1Ops`, and `op1`, but will not depend on `OPS`. Thus a change to `OPS` that `User1` does not care about will not cause `User1` to be recompiled and redeployed.

Let's do another example!

The idea behind this approach is to break down the interface into parts. Classes that are able to implement the original interface can provide several refined interfaces. Other classes can implement only those interfaces which have methods that make sense for them.

At the time you assumed that all cloud providers have the same broa… Amazon. But when … support for another … most of the interfaces … too wide. Some methods describe features that other cloud providers just don't have.



one bloated interface is broken down into a set of more granular interfaces.

not all clients can satisfy the requirements of the bloated interface.

When do we fix ISP?

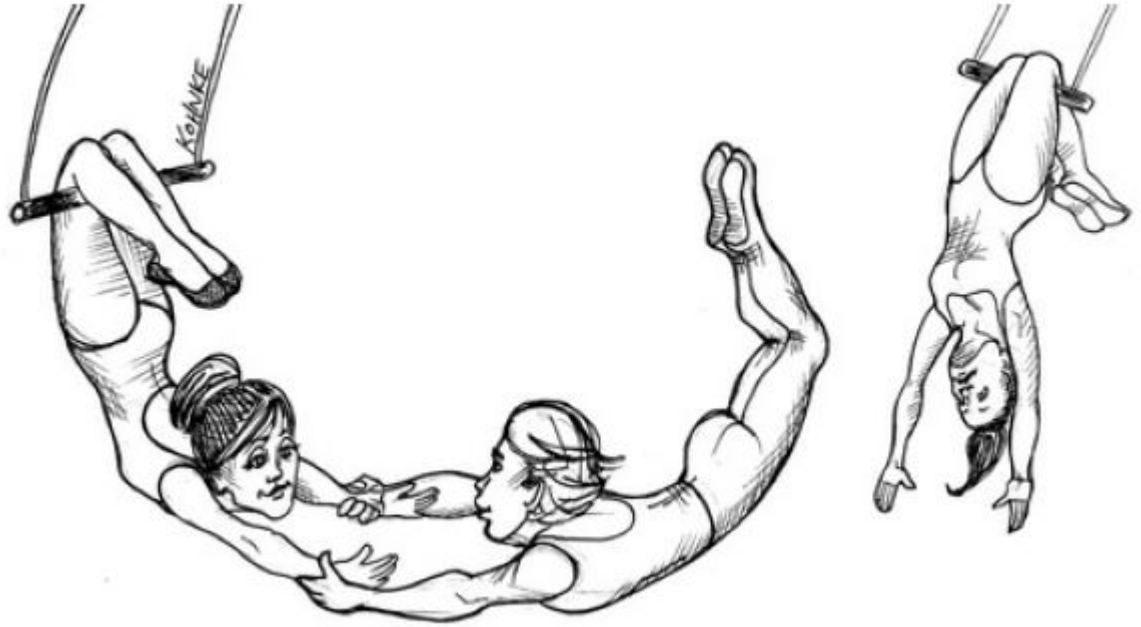
✔ Once there is pain

 If there is no pain, there's no problem to address.

In fat interfaces, there are too many operations, but for most objects, these operations are not used.

Dependency Inversion Principle

- ✔ High level modules shall not depend on low-level modules. Both shall depend on abstractions.
- ✔ Abstractions shall not depend on details. Details shall depend on abstraction pain, there's no problem to address.



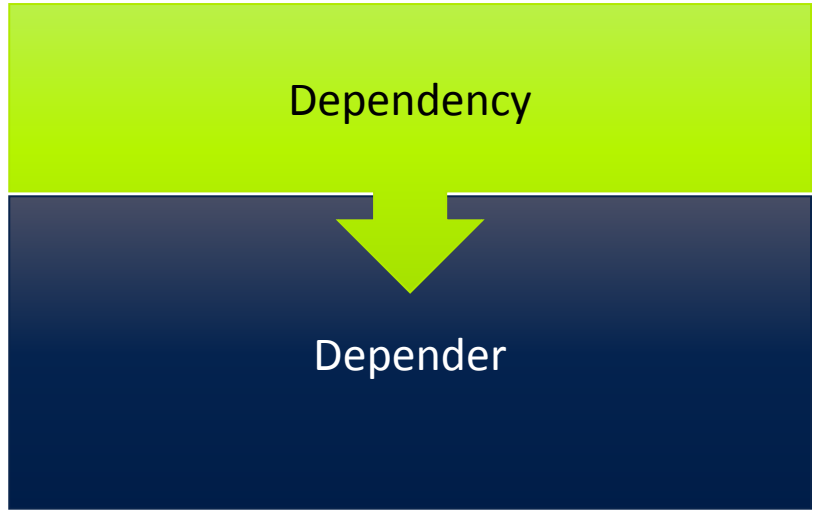
most flexible systems are those in which source code dependencies refer only to abstractions.

Dependency Inversion Principle

What is it that makes a design rigid, fragile and immobile?

It is the interdependence of the modules within that design. A design is rigid if it cannot be easily changed. Such rigidity is due to the fact that a single change to heavily interdependent software begins a cascade of changes in dependent modules.”

- Robert Martin



What is Dependency

A dependency is something - another class, or a value - that your class depends on, or requires. For example:

- If a class requires some setting, it might call *ConfigurationManager.AppSettings["someSetting"].* *ConfigurationManager* is a dependency. The class has a dependency on *ConfigurationManager*.
- If you write two classes - let's say *Log* and *SqlLogWriter* - and *Log* creates or requires an instance of *SqlLogWriter*, then *Log* depends on *SqlLogWriter*. *SqlLogWriter* is a dependency.

DEPENDENCIES….

- ✔ Framework
- ✔ Third Party Libraries
- ✔ Database
- ✔ File System
- ✔ Email
- ✔ Web Services
- ✔ System Resources (Clock)
- ✔ Configuration
- ✔ The new Keyword
- ✔ Static methods
- ✔ Thread.Sleep
- ✔ Random

High Level Modules and Low Level Modules

Forget modules and think about classes.

The principle says that “both should depend on abstractions.” means that when it comes to applying the principle, the difference between high level and low level doesn’t matter.

What Are Abstractions?

- ✔ Abstractions refer to interfaces or abstract classes that define a contract or API for specific behaviors.
- ✔ Details refer to the concrete implementations of those behaviors.

DIP: Let's look at a very simple example

- Suppose you are building a simple system for sending messages. Initially, you have two classes: **`SMS`** and **`Email`** for sending SMS and email messages, respectively:

```
class SMS {
    public void sendSMS(String message) {
        // Code to send an SMS
    }
}

class Email {
    public void sendEmail(String message) {
        // Code to send an email
    }
}
```

DIP: Let's look at a very simple example

- You also have a high-level class called **`MessageSender`** that uses these classes to send messages:

```
class MessageSender {
    private SMS sms;
    private Email email;

    public MessageSender() {
        sms = new SMS();
        email = new Email();
    }

    public void sendSMS(String message) {
        sms.sendSMS(message);
    }

    public void sendEmail(String message) {
        email.sendEmail(message);
    }
}
```

- In this design, the **`MessageSender`** class directly depends on the low-level classes **`SMS`** and **`Email`**.
- This violates the DIP because high-level modules should not depend on low-level modules.

DIP: Let's look at a very simple example

- ✔ To apply DIP, we can introduce an abstraction (interface) that both **`SMS`** and **`Email`** will depend on.
- ✔ That will allow the **`MessageSender`** class to depend on the abstraction instead of the concrete implementations:

```
interface MessageService {
    void sendMessage(String message);
}
class SMS implements MessageService {
    public void sendMessage(String message)
{
        // Code to send an SMS
    }
}
class Email implements MessageService {
    public void sendMessage(String message)
{
        // Code to send an email
    }
}
```

DIP: Let's look at a very simple example

- Now, the **SMS** and **Email** classes implement the **MessageService** interface. We've inverted the dependency, making high-level **MessageSender** depend on the abstraction **MessageService**:

```
class MessageSender {
    private MessageService messageService;

    public MessageSender(MessageService messageService) {
        this.messageService = messageService;
    }

    public void sendMessage(String message) {
        messageService.sendMessage(message);
    }
}
```

With this change, the **MessageSender** class is no longer tightly coupled to the concrete implementations of sending messages. It can work with any class that implements the **MessageService** interface.

PRINCIPLES OF COMPONENT DESIGN

- ✔ If SOLID principles tell us how to arrange the bricks into walls, then the component principles tell us how to arrange the rooms into buildings.
- ✔ Large software systems, like large buildings, are built out of smaller components.
- ✔ Components are smallest entities that can be **deployed** as part of a system.
- ✔ In Java, they are jar files. In Ruby, they are gem files. In .Net, they are DLLs.
- ✔ well-designed components always retain the ability to be **independently deployable** and, therefore, **independently developable**.

PRINCIPLES OF COMPONENT DESIGN

They are divided into two categories:

- ✔ **Principles of Component Cohesion** which focus on the granularity of components and help the developer partition classes into components
- ✔ **Principles of Component Coupling** which focus on the stability and relationships between the components.

COMPONENT COHESION

Which classes belong in which components?

Three principles of component cohesion:

- **REP:** The Reuse/Release Equivalence Principle
- **CCP:** The Common Closure Principle
- **CRP:** The Common Reuse Principle

THE REUSE/RELEASE EQUIVALENCE PRINCIPLE

- ✔ Classes and modules that are grouped together into a component should be releasable together.
- ✔ is closely related to versioning and release management in software development.
- ✔ It suggests that software components should be **organized and released** based on their **reuse potential,** meaning that components that are likely to be **reused together** should be **packaged and versioned** together.
- ✔ Reuse/Release Equivalence Principle emphasizes that the organization of components and their versioning should align with their patterns of reuse.

What is reuse?

THE COMMON CLOSURE PRINCIPLE

Gather into components those classes that change for the same reasons and at the same times.

Separate into different components those classes that change at different times and for different reasons

Just as the SRP says that a class should not contain multiples reasons to change, so the Common Closure Principle (CCP) says that a **component should not have multiple reasons to change**.

THE CLASSES IN A PACKAGE SHOULD BE CLOSED TOGETHER AGAINST THE SAME KINDS OF CHANGES. A CHANGE THAT AFFECTS A PACKAGE AFFECTS ALL THE CLASSES IN THAT PACKAGE.

THE COMMON REUSE PRINCIPLE

THE CLASSES IN A PACKAGE ARE REUSED TOGETHER. IF YOU REUSE ONE OF THE CLASSES IN A PACKAGE, YOU REUSE THEM ALL.

Don’t force users of a component to depend on things they don’t need.

CRP is another principle that helps us to decide which classes and modules should be placed into a component. It states that classes and modules that tend to be reused together belong in the same component.

CRP says that classes that are not tightly bound to each other should not be in the same component.

COMPONENT COUPLING

Relationships between components

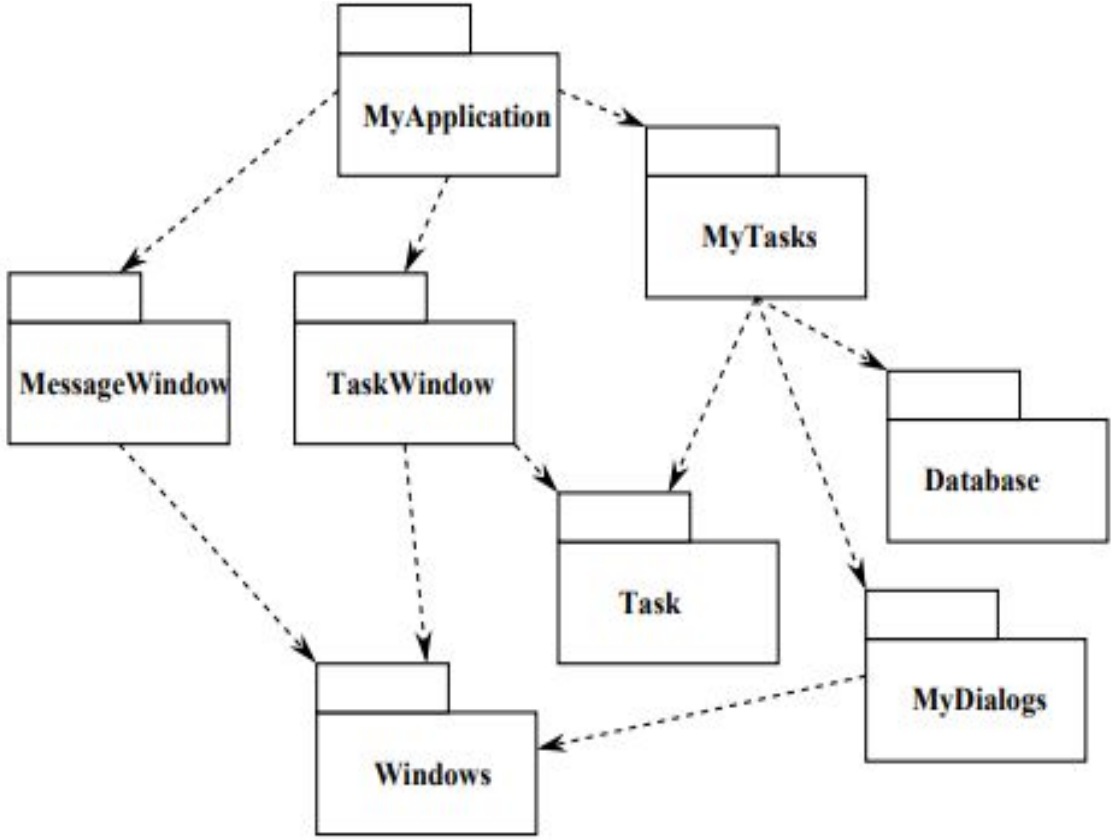
Three principles of component Coupling:

- The Acyclic Dependencies Principle
- The Stable Dependencies Principle
- The Stable Abstractions Principle

THE ACYCLIC DEPENDENCIES PRINCIPLE

- ✔ THE DEPENDENCY STRUCTURE BETWEEN PACKAGES MUST BE A DIRECTED ACYCLIC GRAPH (DAG).
- ✔ THAT IS, THERE MUST BE NO CYCLES IN THE DEPENDENCY STRUCTURE.

The Morning after Syndrome



Suppose **MyDialogs** need to make a new release.

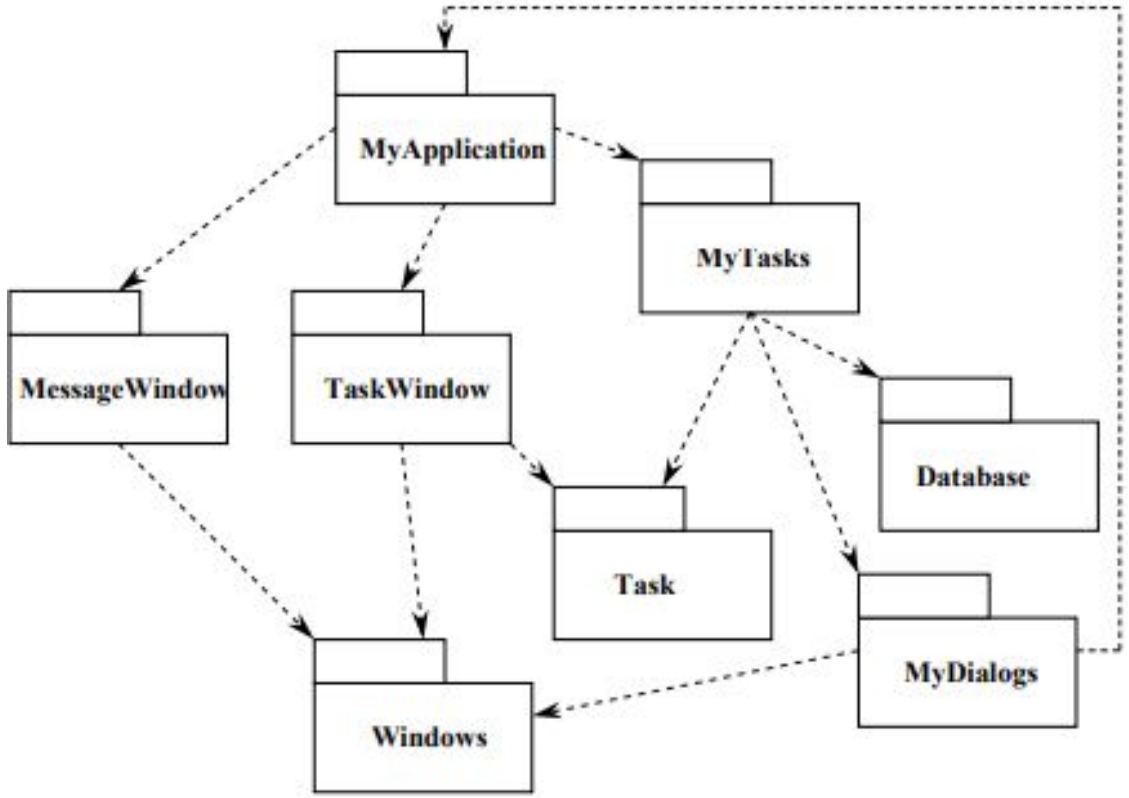
- who is affected by this release
  - MyTasks and MyApplication

The teams responsible for those packages will have to decide when they should integrate with the new release of MyDialogs.

other packages in the system don't know about MyDialogs and they don't care when it changes.

Means that the impact of releasing MyDialogs is relatively small.

THE ACYCLIC DEPENDENCIES PRINCIPLE



What problems will occur with this new cycle

- To release MyTask, it must be compatible with Task, MyDialogs, Database, and Windows.
- But, with the cycle in place, it must now also be compatible with MyApplication, TaskWindow and MessageWindow.
- That is, MyTasks now depends upon every other package in the system.

MyDialogs suffers the same fate.

In fact, the cycle has the effect that MyApplication, MyTasks, and MyDialogs must always be released at the same time.

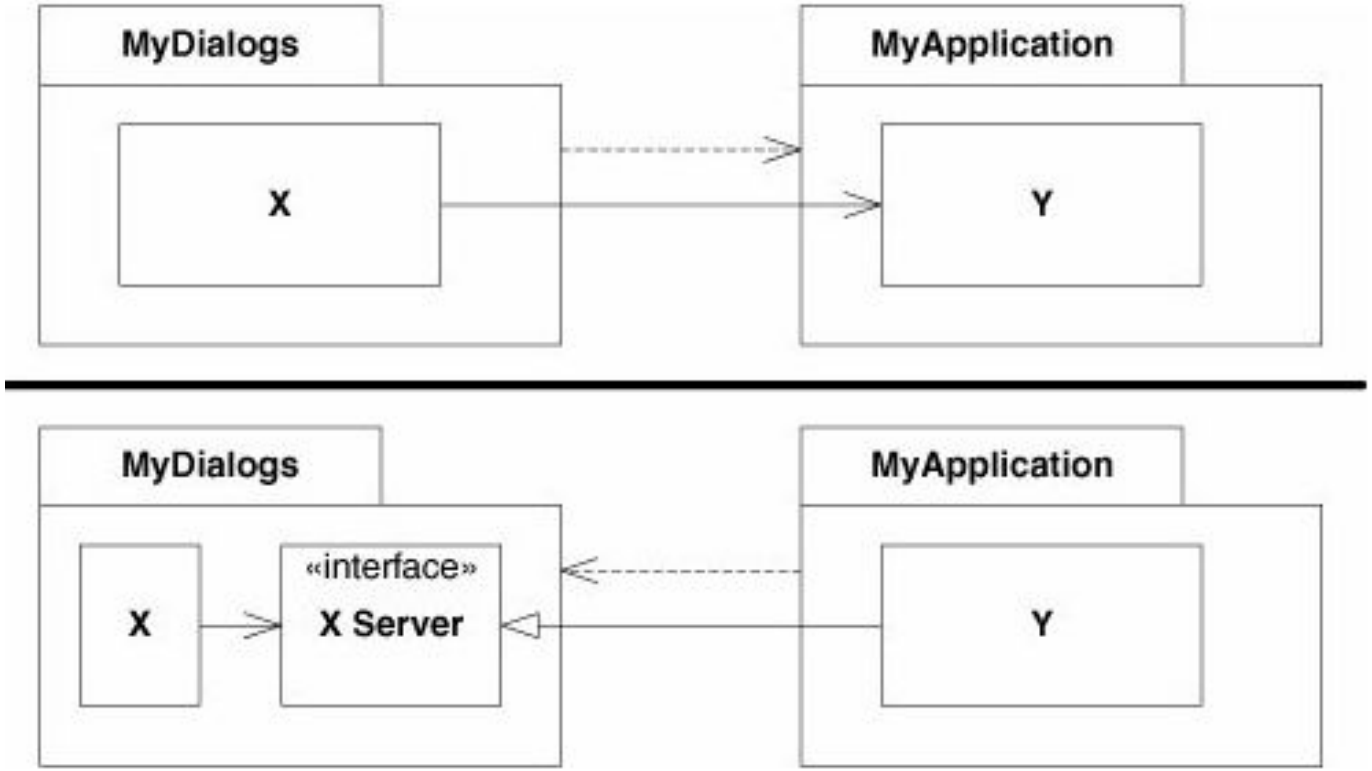
And all the engineers who are working in any of those packages will experience “the morning after syndrome” once again.

How to Fix

1. Apply the Dependency Inversion Principle (DIP).
2. Create a new package that both MyDialogs and MyApplication depend upon. Move the class(es) that they both depend upon into that new package.

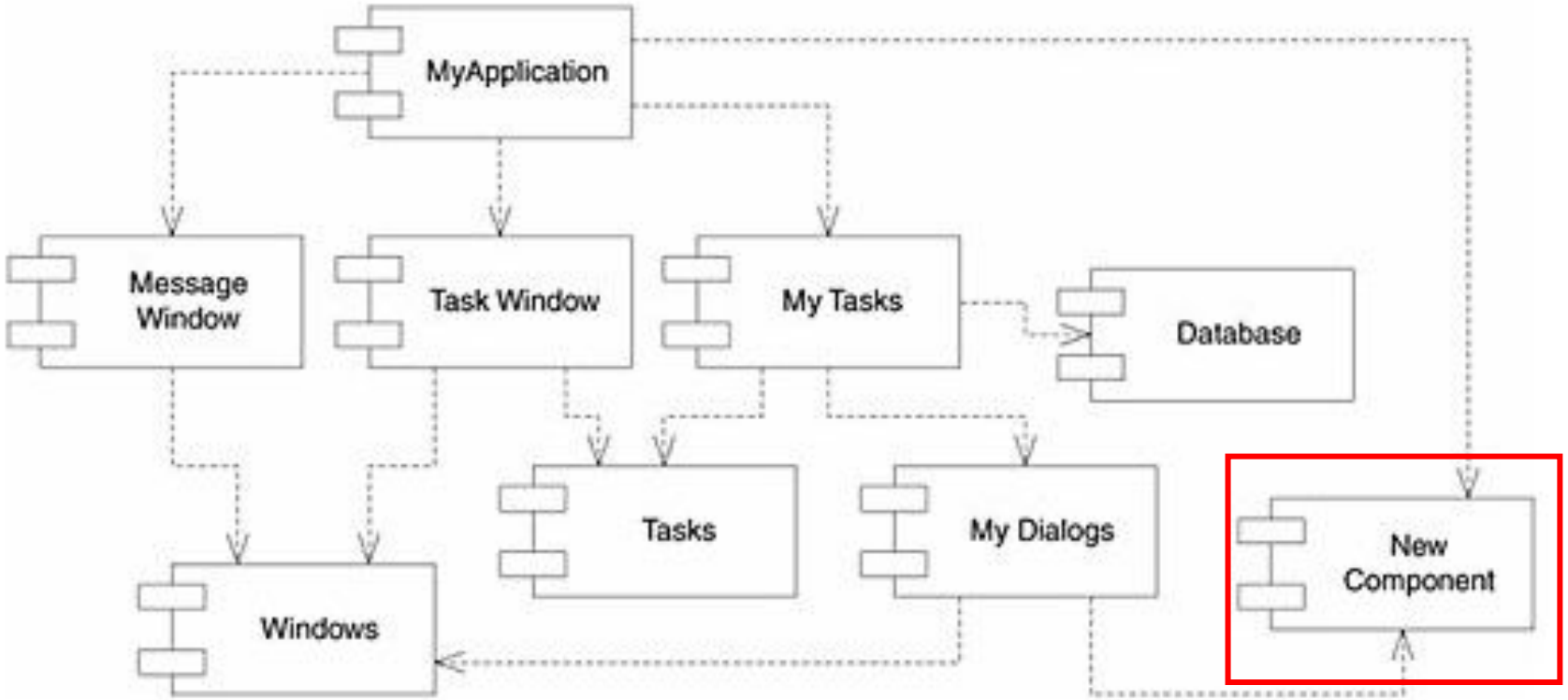
THE ACYCLIC DEPENDENCIES PRINCIPLE

Apply the Dependency-Inversion Principle (DIP) we could create an **abstract base class** that has the **interface** that `MyDialogs` needs. We could then put that abstract base into `MyDialogs` and inherit it into `MyApplication`. This inverts the dependency between `MyDialogs` and `MyApplication`, thus breaking the cycle.



THE ACYCLIC DEPENDENCIES PRINCIPLE

Create a `new component` that both `MyDialogs` and `MyApplication` depend on. Move the class(es) that they both depend on into that new component.



THE STABLE DEPENDENCIES PRINCIPLE

Depend in the direction of stability

Stability is related to the amount of work required to make a change.
"**Stable**" roughly means "**hard to change**", whereas "**instable**" means "**easy to change**"

A component with lots of incoming dependencies is very stable because it requires a great deal of work to reconcile any changes with all the dependent components.

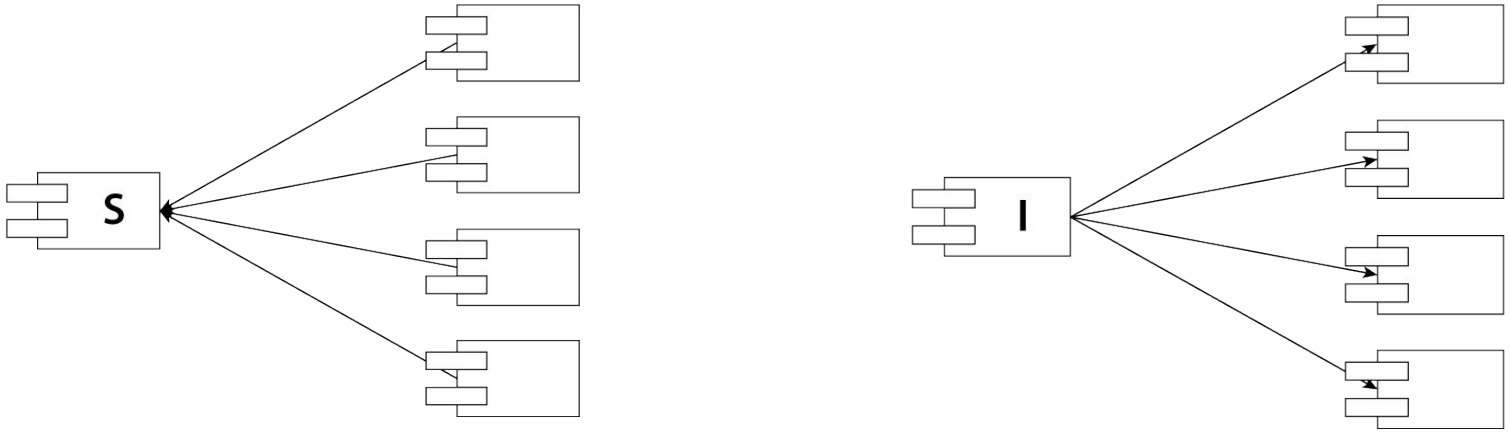


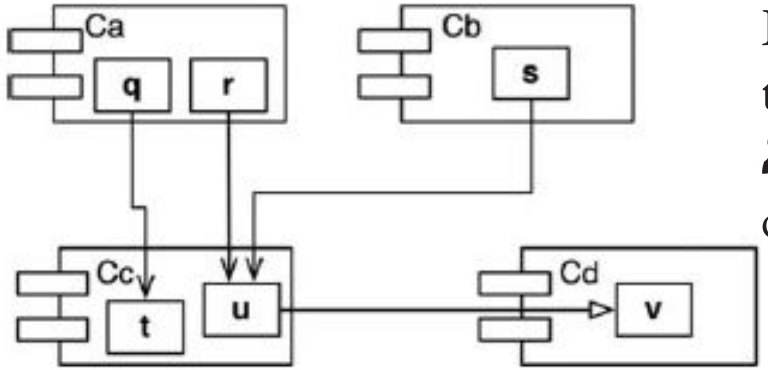
Figure shows S, which is a stable component. Four components depend on S, so it has four good reasons not to change. We say that S is **responsible** to those four components. Conversely, *I* depends on nothing, so it has no external influence to make it change. We say it is **instable**.

Calculating Components stability

Fan-in: Incoming dependencies. This metric identifies the number of classes outside this component that depend on classes within the component.

• *Fan-out*: Outgoing dependencies. This metric identifies the number of classes inside this component that depend on classes outside the component.

• *I*: Instability: *I* = *Fan-out* / (*Fan-in* + *Fan-out*). This metric has the range [0, 1]. 0 indicates a maximally stable component. 1 indicates a maximally unstable component.



Let's say we want to calculate the stability of the component Cc. We find that there are three classes outside Cc that depend on classes in Cc. Thus, **Fan-in** = 3. Moreover, there is one class outside Cc that classes in Cc depend on. Thus, **Fan-out** = 1 and **I** = 1/4.

Not All Components Should Be Stable

THE STABLE ABSTRACTIONS PRINCIPLE

The more stable a component is, the more abstract it should be

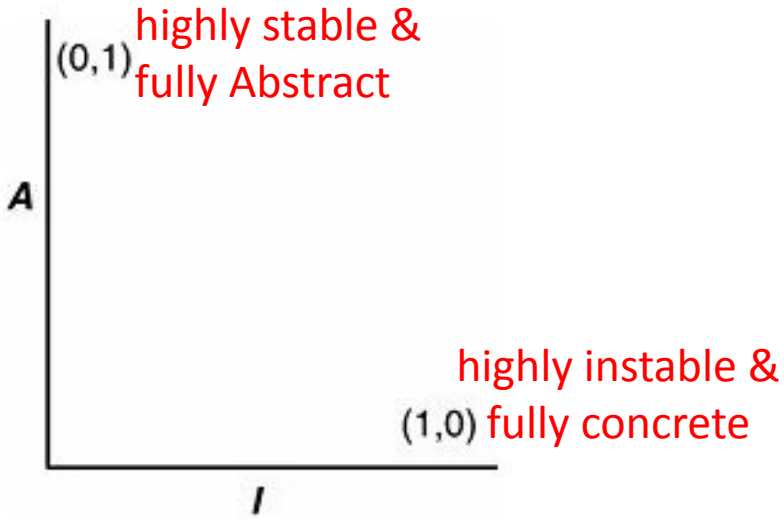
The Stable Abstractions Principle (SAP) sets up a relationship between stability and abstractness.

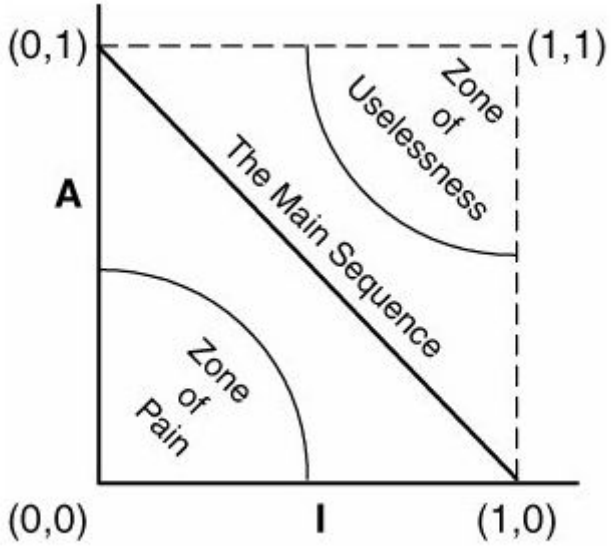
if a component is to be stable, it should consist of interfaces and abstract classes so that it can be extended.

How abstract a component is simply the ratio of interfaces and abstract classes in a component to the total number of classes in the component.

Nc: The number of classes in the component.
Na: The number of abstract classes and interfaces in the component.
A: Abstractness. **A = Na / Nc.**
The **A** metric ranges from 0 to 1. A value of 0 implies that the component has no abstract classes at all. A value of 1 implies that the component contains nothing but abstract classes.

RELATIONSHIP BETWEEN STABILITY (I) AND ABSTRACTNESS (A)





Consider a component in the area near (0,0). This component is highly stable and concrete. Such a component is not desirable, because it is rigid. It cannot be extended, because it is not abstract. And it is very difficult to change, because of its stability.

SUMMARY

The first three package principles are about package *cohesion*

REP	The Release Reuse Equivalency Principle	*The granule of reuse is the granule of release.*
CCP	The Common Closure Principle	*Classes that change together are packaged together.*
CRP	The Common Reuse Principle	*Classes that are used together are packaged together.*

Other three principles are about the couplings between packages

ADP	The Acyclic Dependencies Principle	*The dependency graph of packages must have no cycles.*
SDP	The Stable Dependencies Principle	*Depend in the direction of stability.*
SAP	The Stable Abstractions Principle	*Abstractness increases with stability.*

Next Class

After Mid