SOLID

...and other OO principles!

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Index

Software Rot   Symptoms   Causes   SOLID Principles   Other Principles

Reference

Directly from Uncle Bob:

> *Martin, R.C., 2000. "Design principles and design patterns". Object Mentor, 1(34), p.597.*

Software Rot

Software Rot

Even when software design **starts** as a **pristine work of art**, portraying the **clean** and **elegant** image in the **mind** of the designer, it **eventually** starts to **rot**:

- It starts with a **small hack** but the overall beauty of the design is still there.
- The hacks start **accumulating**, each one another **nail** in the **coffin**.
- The code **eventually** becomes an incredibly **hard to maintain** mess.

System Redesign

- At this point a **redesign** is needed. But the old code is still in **production**, **evolving** and **changing**.
- So the *system redesign* is trying to **shoot** at a **moving target**.
- **Problems** start to **accumulate** in the new design **before** it is even **released**.

Symptoms of Rotting Design

Rigidity

- The **tendency** for software to be **difficult** to **change**.
- Every **change** causes a **cascade** of subsequent **changes**.

When software behaves this way, managers **fear** to allow engineers to **fix** non-critical **problems** (as they may disappear for long periods of time).

Fragility

- The **tendency** of software to **break** in **many places** every time it is changed.
- Often in areas that have **no conceptual relationship** with the area that was changed.

When software behaves this way, managers and customers start to suspect that the **developers** have **lost control** of their software.

Immobility

- The **inability** to **reuse software** from other projects or from parts of the same project.
- The **work** and **risk** required to **separate** the desirable parts of the software from the undesirable parts are **too great** to tolerate.

Software ends up being **rewritten**.

Viscosity

Viscosity of the **design**:

- There is **more than one** way to make a change: preserving the **design**, and **hacks**.
- The **design** preserving methods are **harder** to employ than the **hacks**.

Viscosity of the **environment**:

- The development environment is **slow** and **inefficient** (long compile times, complicated and long check in procedures, ...).
- Developers end up choosing solutions that require **as few changes** as possible, **regardless** of whether the **design** is **preserved**.

Causes of Rotting Design

Changing Requirements

- **Requirements** change in ways that the **initial design** did **not anticipate**.
- Often **changes** are **urgent**, and **hacks** are **used** to make them; even if it **deviates** from the original design.

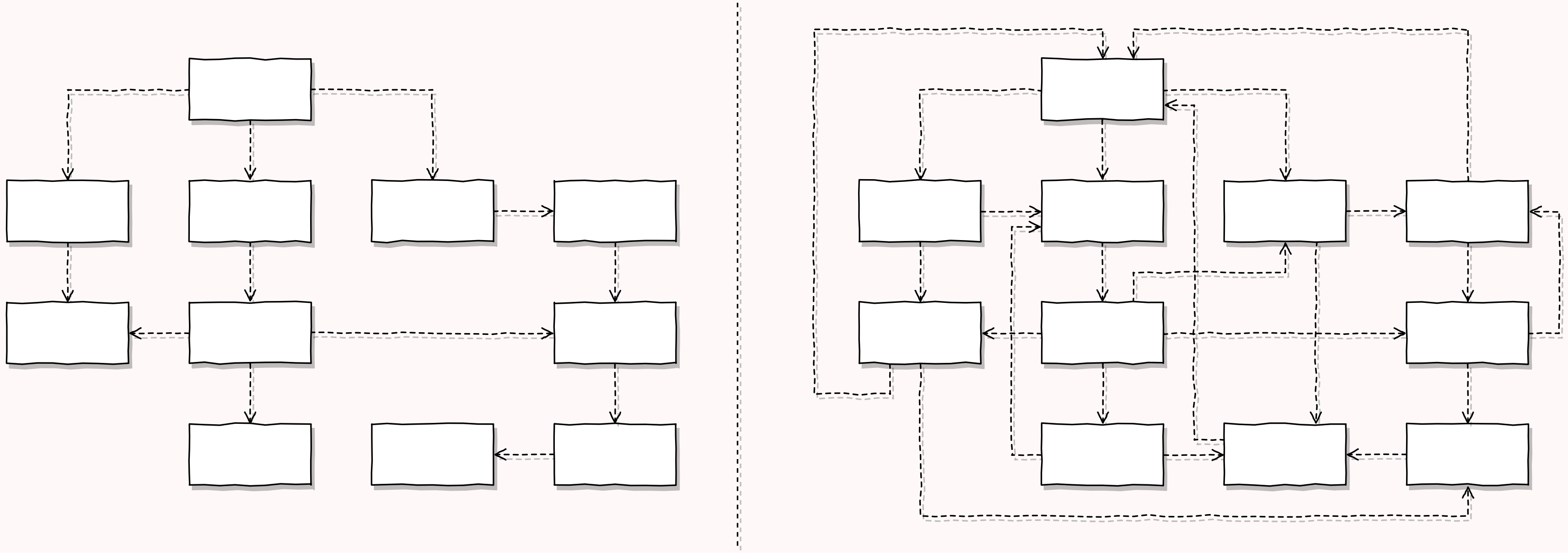
Changing requirements should **not** be **a surprise**, and blaming them is the **easy way out**:

- The **system design** must be **resilient** to these changes from the start.

Dependency Hell

If we **analyze** the four **symptoms** of rotting design just presented, carefully, there is one **common theme** among them: **improper dependencies** between modules.

- The **initial design** properly separates the **responsibilities** of each module; dependencies seem **logic** and **stratified**.
- As **time** goes by, **hacks** (needed because of **unforseen requirement changes**), introduce **unwanted** dependencies.



Principles of Object-Oriented Design

SOLID

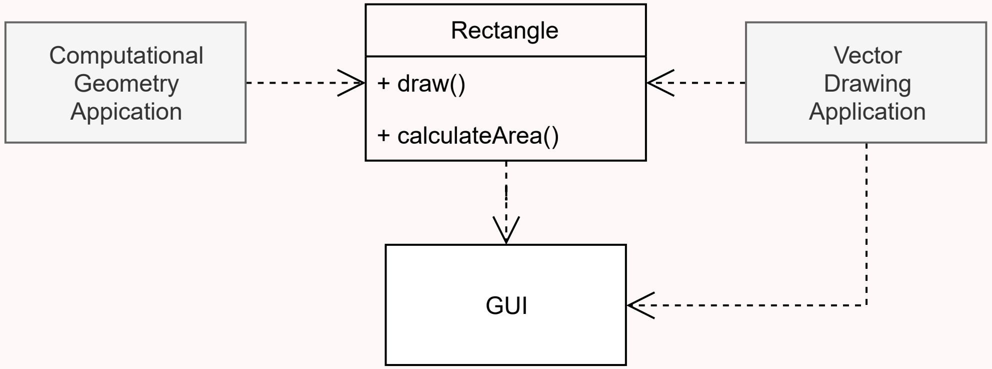
(S) The Single Responsibility Principle (SRP)

> *"Each software module should have **one** and **only one reason** to **change**."*

If a module assumes more than one responsibility, then:

- There will be **more than one reason** for it to **change**.
- **Changes** to one responsibility may **impair** the **ability** to **meet** the **others**.
- It might **force unwanted** and **unneeded dependencies**.

Example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Rectangle
+ draw()
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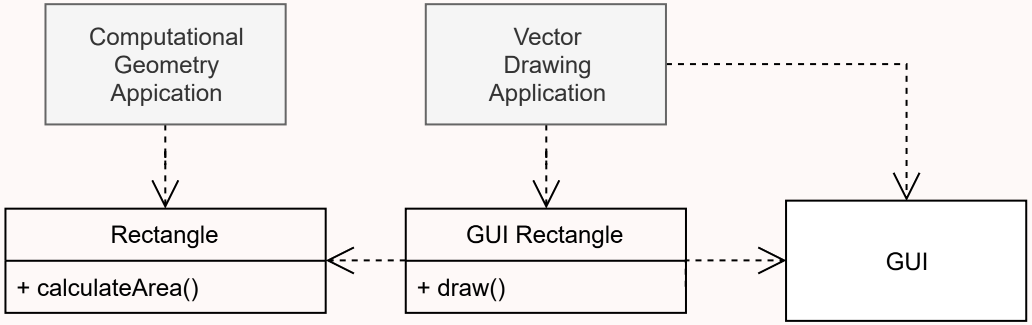
Application
GUI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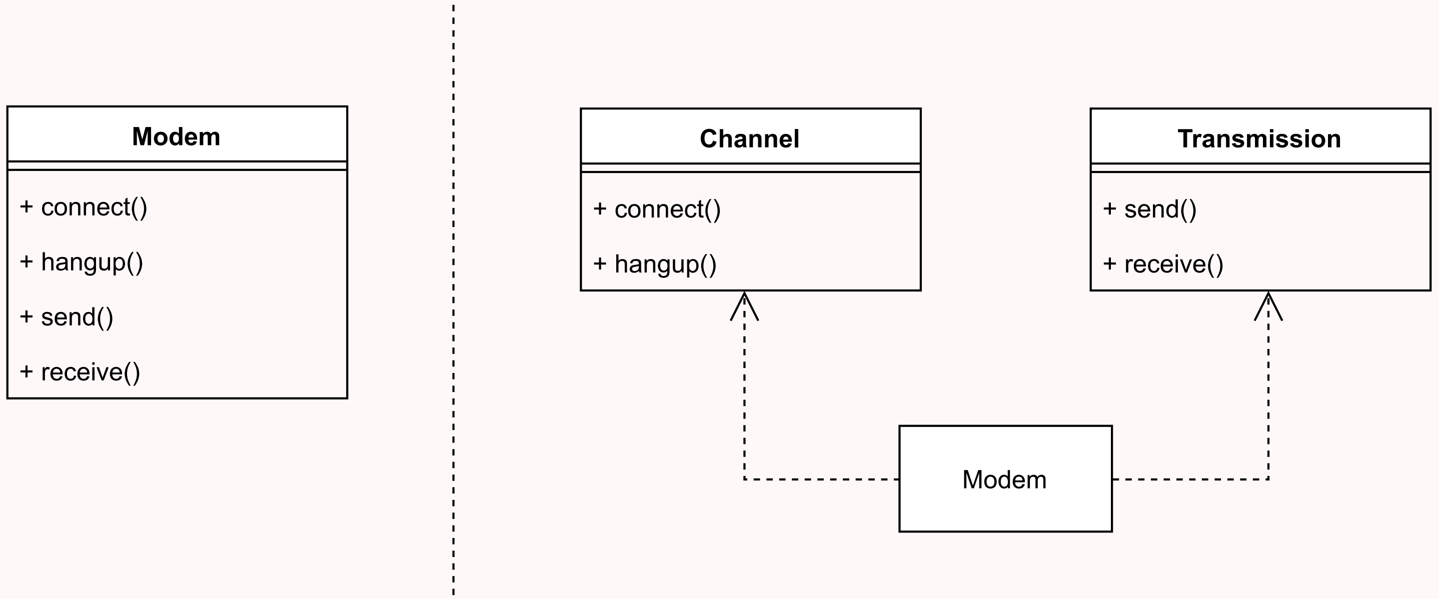
When to (or not to) use?



> *Gather together the things that change for the same reasons. Separate those things that change for different reasons — Uncle Bob, 2014*

- If the application is **not changing** in ways that cause the two responsibilities to **change at different times**, then there is **no need to separate them**.
- It is **not wise** to apply the SRP if there is **no symptom** (needless complexity).

Hiding Difficult Decisions

> *“We have tried to demonstrate by these examples that it is almost always incorrect to begin the decomposition of a system into modules on the basis of a flowchart. We propose instead that one begins with a list of **difficult design decisions** or design decisions which are **likely to change**. Each module is then designed to **hide such a decision from the others**.”*

— Parnas, D.L., 1972. **On the criteria to be used in decomposing systems into modules**. Communications of the ACM, 15(12), pp.1053-1058.

(O) The Open-Closed Principle (OCP)

> *A module should be **open** for extension but **closed** for modification.*

- We should **write** our modules so that they **can** be **extended**, **without requiring** them to be **modified**.
- So we can **add** new features to **existing** code, by only **adding** (and not modifying) new code.

Example

There can be **many different** types of shapes:

```java
public class Shape {
    enum TYPE {SQUARE, CIRCLE}
    private TYPE type;

    public void draw() {
        switch (type) {
            case CIRCLE: drawCircle(); break;
            case SQUARE: drawSquare(); break;
        }
    }
}
```

What **happens** when we want to **add another** shape?

Solution: Dynamic Polymorphism

```java
public abstract class Shape {
    public void draw();
}
```

```java
public class Square extends Shape {
    public void draw() {
        //...
    }
}
```

```java
public class Circle extends Shape {
    public void draw() {
        //...
    }
}
```

Other Solution: Static Polymorphism

Also known as **generics** (more on that later):

```
List<String> listOfStrings;
List<Shape> listOfShapes;
```

No need to **rewrite** the *List* class to use it with a **different** type.

(L) The Liskov Substitution Principle (LSP)

> *Subclasses should be substitutable for their base classes.*

A **user** of a **base class** should **continue** to **function properly** if a **derivative** of that base class is **passed** to it.

This might seem **obvious** at first, but many times its **hard to detect** that this principle is being **broken**.

The Rectangle-Square Dilemma

All **squares** are **rectangles** with **equal height** and **width**.

```
public class Rectangle {
  public void setWidth(double width);
  public void setHeight(double height);
  public double getArea();
}

public class Square extends Rectangle {
  public void setWidth(double width) {
    this.width = width; this.height = width;
  }
  public void setHeight(double height) {
    this.width = height; this.height = height;
  }
}
```

LSP Violation

A **client** should **rightfully** expect the following to **hold**:

```
public void doSomething(Rectangle r) {
  r.setWidth(10);
  r.setHeight(20);
  assertEquals(200, r.getArea());
}
```

If this method really **needs** this to hold, then it has to **test** if the Rectangle is **really** a Rectangle:

```
public void doSomething(Rectangle r) {
  if (!(r instanceof Square) {
    // ...
  }
}
```

And we are back at the **OCP** problem!

LSP as Contracts

A **derived** class is **substitutable** for its **base** class if:

1. Its **preconditions** are no **stronger** than the **base** class method.
2. Its **postconditions** are no **weaker** than the **base** class method.

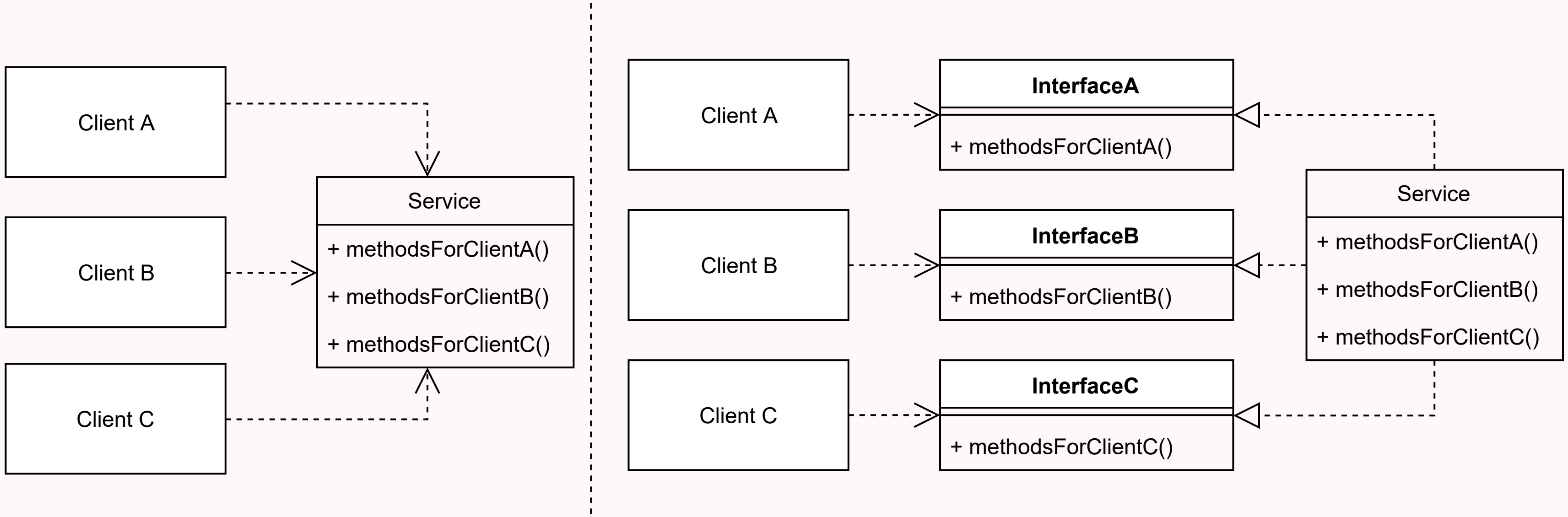
Or, in other words, **derived methods should expect no more and provide no less**.

(I) The Interface Segregation Principle (ISP)

> ***Many client specific*** *interfaces are better than* ***one general purpose*** *interface.*

- Clients should **not be forced** to **depend** upon **interfaces** that they **do not use**.
- Clients should be **categorized** by their **type**, and **interfaces** for **each type** of client should be **created**.
- If **two or more** different client types **need** the **same method**, the method should be **added** to **both** of their interfaces.

One Service, Different Interfaces



- Makes the code more **readable** and **manageable**.
- Promotes the **single responsibility principle** (SRP).

(D) The Dependency Inversion Principle (DIP)

> ***High-level*** *modules should* ***not depend*** *on* ***low-level*** *modules.* ***Both*** *should* ***depend*** *on* ***abstractions****.*

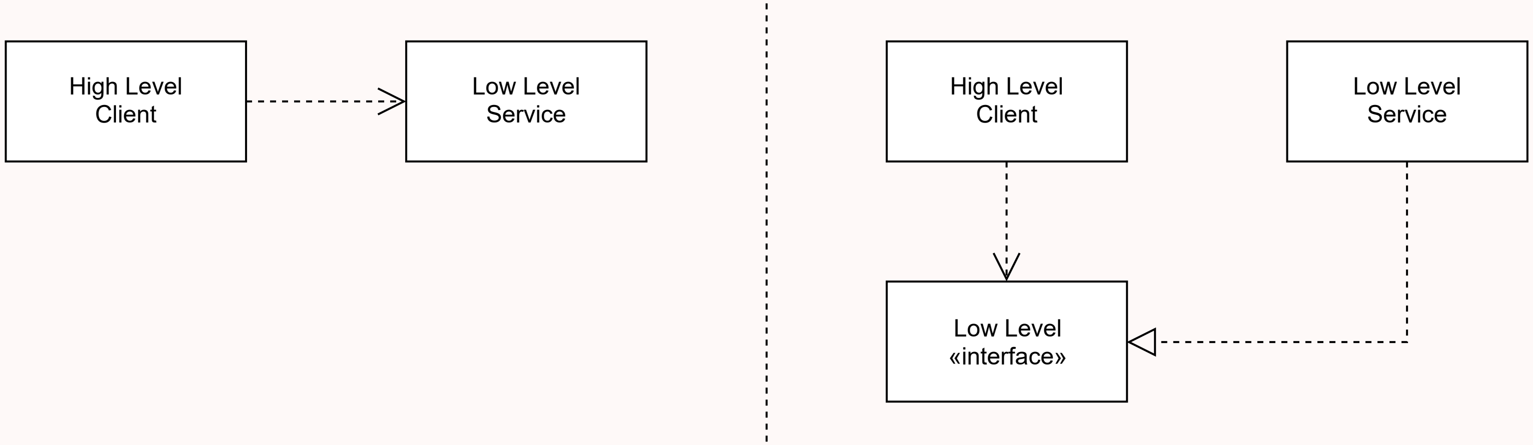
And

> ***Abstractions*** *should* ***not depend*** *on* ***details****.* ***Details*** *should* ***depend*** *on* ***abstractions****.*

- We are **not just** changing **the direction** of the dependency.
- We are **splitting** the **dependency** by putting an **abstraction** in the **middle**.

Why?

Concrete things change a **lot**, **abstract** things change much **less** frequently.



- No client code has to be **changed** simply because an object it **depends** on needs to be **changed** to a **different one** (loose coupling).
- Promotes **testability**.
- Promotes **replaceability**.

Other Principles

Principles of Package Architecture

The Release Reuse Equivalency Principle (REP)

> *The granule of reuse is the granule of release.*

- Code should **not be reused** by **copying** it from one class and **pasting** it into another.
- Only **components** that are **released** through a **tracking system** can be **effectively reused**.

The Common Closure Principle (CCP)

> *Classes that change together, belong together.*

- If the code in an application **must change**, changes should be **focused** into a **single package**.
- If two classes almost **always change together**, then they **belong** in the **same package**.

Maintainability!

The Common Reuse Principle (CRP)

> *Classes that **aren't reused** together **should not** be **grouped** together.*

- Generally **reusable** classes **collaborate** with other classes that are part of the **reusable** abstraction.
- These classes **belong** in the **same** package.

Reusability!

The Package Coupling Principles

The Acyclic Dependencies Principle (ADP)

> *The **dependencies** between packages **must not form cycles**.*

- The **dependency graph** should be a **DAG** (directed **acyclic** graph).
- **Cycles** in the dependency graph are **effectively large packages**.
- Cycles can be **broken** using the **dependency inversion principle** (DIP).

The Stable Dependencies Principle (SDP)

> *Depend in the direction of stability.*

- **Stable** means "**hard** to **change**" (many clients), while **unstable** means "**easy** to **change**".
- Modules that are "**hard to change**" should **not depend** on modules that are "**easy to change**".
- The reason is that it makes the "**easy to change**" module "**harder to change**" because of the **impact** on the depending module.
- You need "**easy to change**" packages, or your software **cannot change easily**.

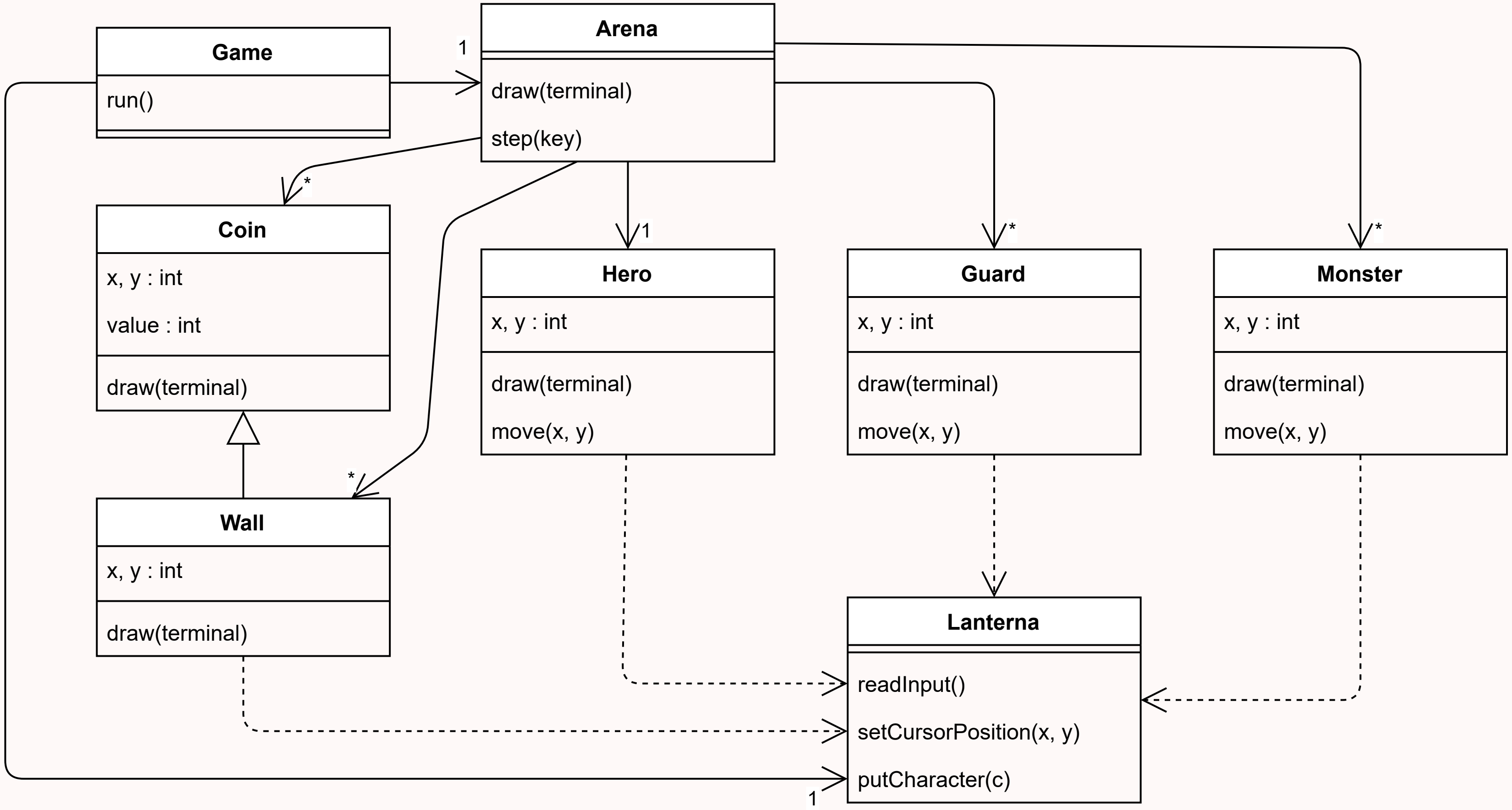
The Stable Abstractions Principle (SAP)

> *Stable packages should be abstract packages.*

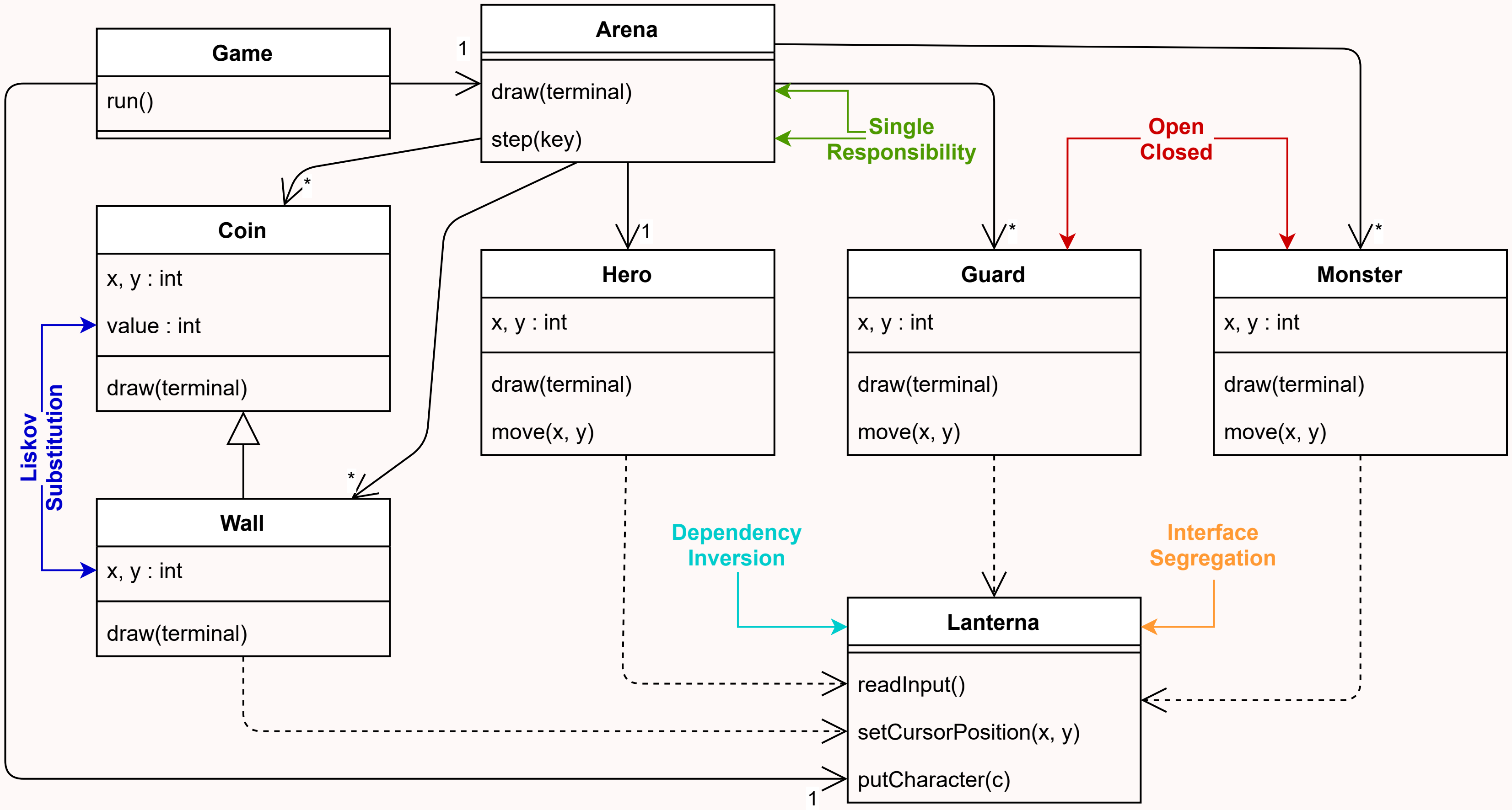
- A package can be said to be "**harder to change**" as **more packages depend** on it.
- So it should be made **abstract** so that it can be **extended** when necessary.
- A package that is **not used** by other packages can be "**changed easily**", so it can remain **concrete**.

An Example

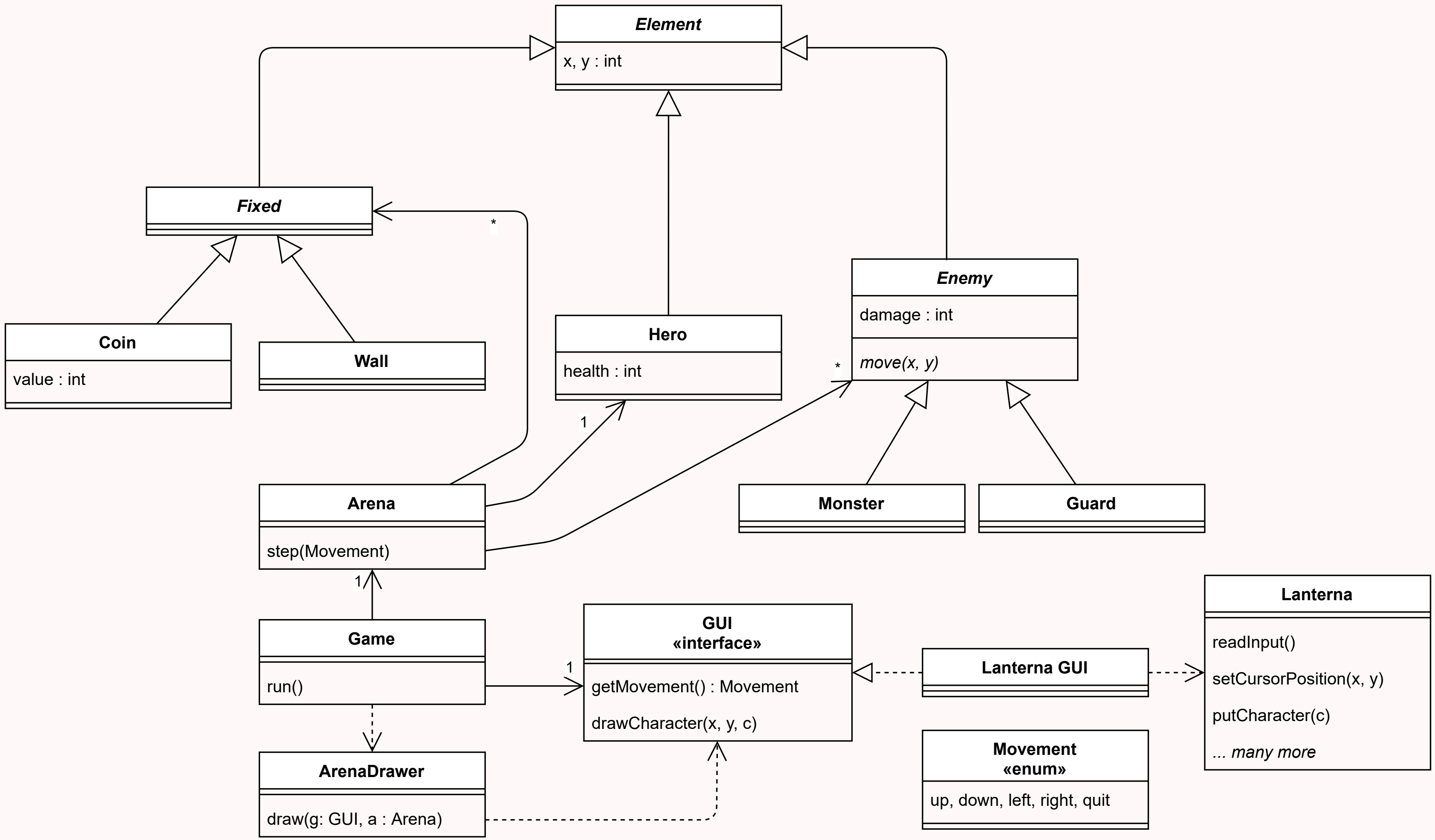
Bad Design


Game
run()
1
Arena
draw(terminal)
step(key)
*
Coin
x, y : int
value : int
draw(terminal)
1
Hero
x, y : int
draw(terminal)
move(x, y)
*
Guard
x, y : int
draw(terminal)
move(x, y)
*
Monster
x, y : int
draw(terminal)
move(x, y)
*
Wall
x, y : int
draw(terminal)
Lanterna
readInput()
setCursorPosition(x, y)
putCharacter(c)
1

Violated Principles



Solid Design


Element
x, y : int
Fixed
*
Coin
value : int
Wall
Hero
health : int
Enemy
damage : int
move(x, y)
*
1
Monster
Guard
Arena
step(Movement)
1
Game
run()
1
GUI
«interface»
getMovement() : Movement
drawCharacter(x, y, c)
Lanterna GUI
Lanterna
readInput()
setCursorPosition(x, y)
putCharacter(c)
... many more
ArenaDrawer
draw(g: GUI, a : Arena)
Movement
«enum»
up, down, left, right, quit