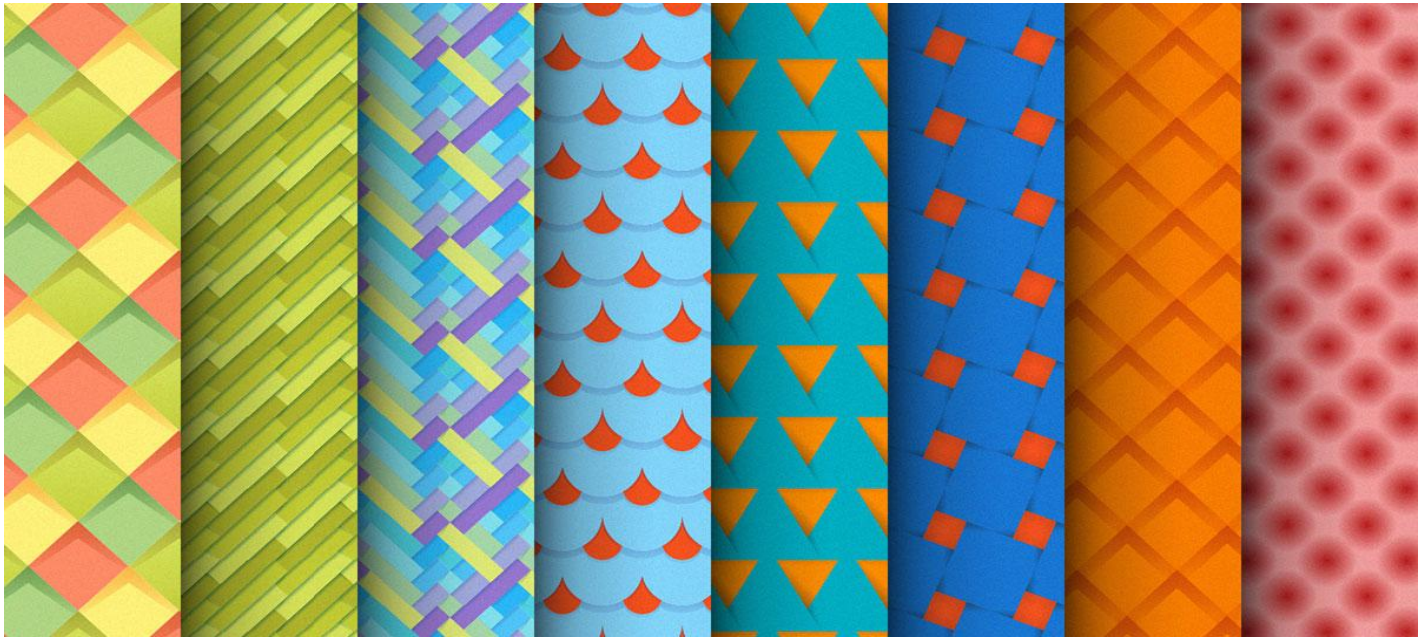
DESIGN PATTERNS

COURSE 2



CONTENT

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  - Encapsulation
  - Inheritance
  - Abstractisation
  - Polymorphism
  - [Exception Handling]
- **Fundamental Patterns**
  - Inheritance
  - Delegation
  - Interface
  - Abstract superclass
  - Inheritance and abstract superclass
  - Immutable objects
  - Marker interface
- **OOD key principles**
  - SRP – Single Responsibility Principle
  - OCP - Open Close Principle
  - LSP – Liskov Substitution Principle
  - ISP – Interface Segmentation Principle
  - DIP – Dependency Inversion Principle
  - DRY – Don’t Repeat Yourself

FUNDAMENTALS PRINCIPLES OF OOP

- **Objects**
  - Describe characteristics (properties) and behavior (methods) of real life objects
- **Object Oriented language**
  - Encapsulation
    - hide unnecessary details and provide a clear and simple interface for working with them
  - Inheritance
    - improve code readability and enable the reuse of functionality
  - Abstraction
    - deal with objects considering their important characteristics and ignore all other details
  - Polymorphism
    - how to work in the same manner with different objects
  - [Error handling]
    - the process of responding to the occurrence, during computation, of *exceptions* – anomalous or exceptional conditions requiring special processing – often changing the normal flow of program execution.

FUNDAMENTALS PRINCIPLES OF OOP. ABSTRACTION

- **Abstraction**
  - Problem -> Model
- **Model**
  - Dates
  - Operations
  - A simplification with a scope of a problem
    - Simple model => accessible code
  - Model Views
    - A view for system major parts interaction
    - A view of system details
    - A view from user point of view
    - …
  - Common notation
    - Unified Modeling Model (UML)

Example

- How does a person see a computer?
  - Child: a device for gaming
  - Electronics: an assembly of circuits and transistors
  - Programmers: an environment for developing tools

FUNDAMENTALS PRINCIPLES OF OOP. ENCAPSULATION

- **Hide unnecessary the properties and behavior of objects**
- **Reduce the necessary knowledge about a class, in order to user it**
  - In many cases the programmer does not need to know implementation details of a class, if the class offers the desired behavior

```
class WithoutEncapsulationOrInformationHide
{
   public static final int STATUS_ACTIVE = 0;
   public static final int STATUS_HALTED = 1;
   public int status = STATUS_ACTIVE;
};
```

FUNDAMENTALS PRINCIPLES OF OOP. ENCAPSULATION

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```
class WithoutEncapsulationOrInformationHide
{
   public static final int STATUS_AC
   public static final int STATUS_HA
   public int status = STATUS_ACTI
};
```

```
class EncapsulationWithoutInformationHide{
public static final int STATUS_ACTIVE = 0;
public static final int STATUS_HALTED = 1;
private int status = STATUS_ACTIVE;
public int getStatus() {
 return status;
 }
};
```

FUNDAMENTALS PRINCIPLES OF OOP. ENCAPSULATION

- **Hide unnecessary the properties and behavior of objects**
- **Reduce the necessary knowledge about a class, in order to user it**
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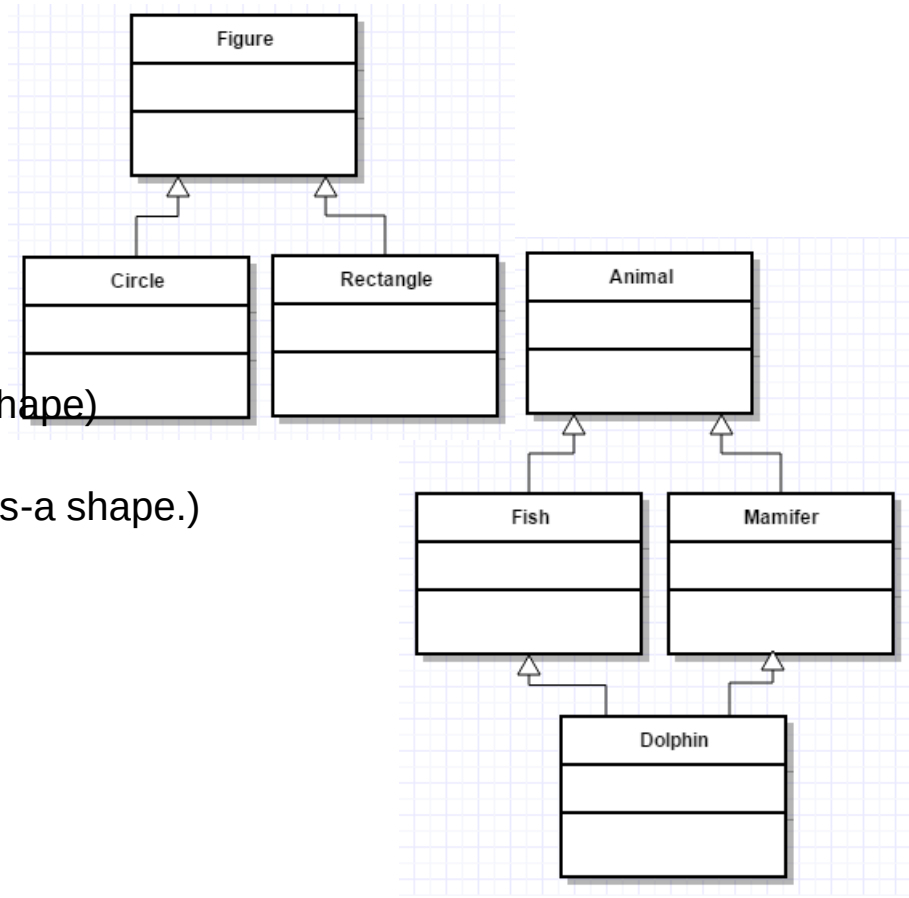
```
class EncapsulationAndInformationHide {
public static final int STATUS_ACTIVE = 0;
public static final int STATUS_HALTED = 1;
private int status = STATUS_ACTIVE;
private int getStatus() {
     return status;
 }
public boolean isActive() {
   return getStatus() == STATUS_ACTIVE;
}
};
```

```
class EncapsulationWithoutInformati
public static final int STATUS_ACTIV
public static final int STATUS_HALTE
private int status = STATUS_ACTIVE
public int getStatus() {
 return status;
 }
};
```

FUNDAMENTALS PRINCIPLES OF OOP. INHERITANCE

- **Inheritance is a mechanism which allows a class A to inherit members (data and functions) of a class B. We say "A inherits from B". Objects of class A thus have access to members of class B without the need to redefine them.**
- **Terminology**
  - Base class
    - The class that is inherited
  - Derived class
    - A specialization of base class
  - Kind-of relation
    - Class level (Circle is a kind-of Shape)
  - Is-a relation
    - Object level (The object circle1 is-a shape.)
- **Types of inheritance**
  - Simple
    - One base class
  - Multiple
    - Multiple base classes



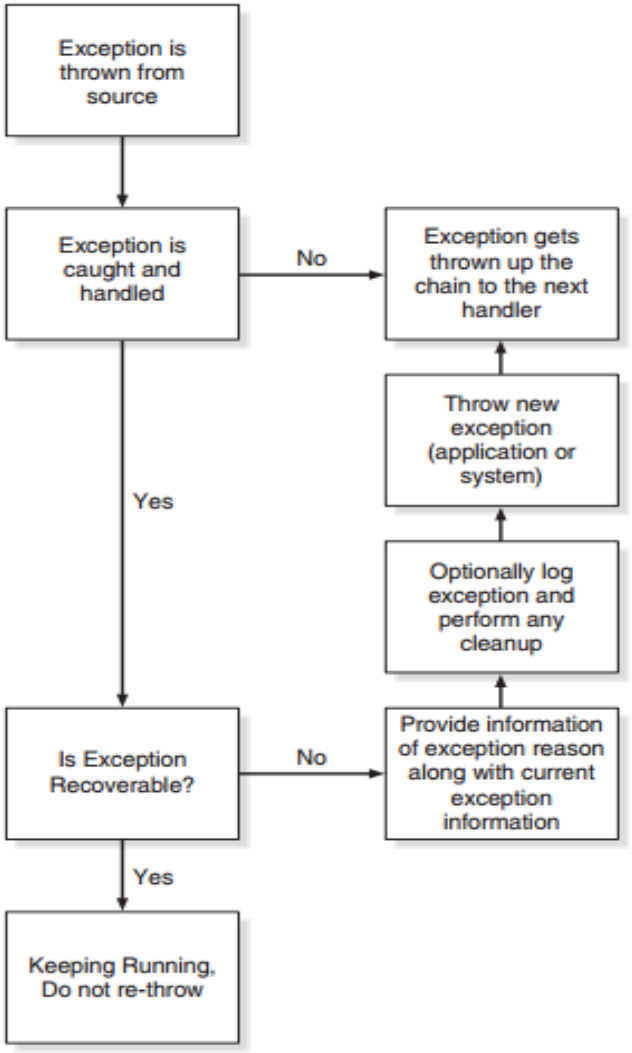
FUNDAMENTALS PRINCIPLES OF OOP. POLYMORPHISM

- **Polymorphism the ability to use a thing in different ways**
  - Run-time
    - Inheritance
    - Virtual functions (C++)
    - Generics (Java)
  - Compile-time
    - Templates (C++)
  - Ad-hoc
    - Operator overloading (in C++)
  - Parametric
    - Casting

FUNDAMENTALS PRINCIPLES OF OOP. ERROR HANDELING

- **An exception is an error that appears at run-time.**
- **Examples**
  - Out of memory
  - File already opened
  - Null pointer exception
- **Variants to resolve such situations**
  - Custom mechanism
    - Program stops -> unacceptable solution
    - Return of an error code -> the state of the program has to test the error code returned
    - A function that is called each time an error occurs -> no control over the caller
  - Using language mechanism of handling exceptions

FUNDAMENTALS PRINCIPLES OF OOP. ERROR HANDELING



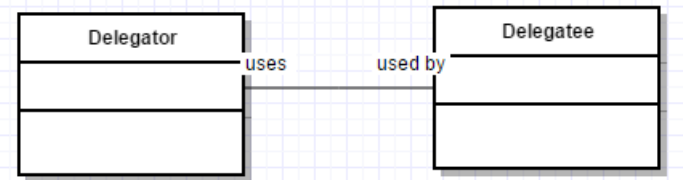
FUNDAMENTAL PATTERNS

- **Fundamentals patterns**
  - Patterns already found permanent in modern programming languages
  - Not classified in other categories

- **Fundamentals patterns types**
  - Inheritance
  - Delegation
  - Interface
  - Abstract superclass
  - Inheritance and abstract superclass
  - Immutable objects
  - Marker interface

FUNDAMENTALS PATTERNS. DELEGATE

- **Intent:**
  - Delegation allows objects to share behavior without using inheritance and without duplicating code
- **Solution:**
  - Delegation is a way of reusing and extending the behavior of a class. It works writing a new class that incorporates the functionality of the original class by using an instance of the original class and calling its methods.
- **Consequences:**
  - Behavior can be changed at run-time (comparing to inheritance that is static)
  - The ‘delegate’ is hidden to delegator’s clients
  - More difficult to implement comparing to inheritance



FUNDAMENTAL PATTERNS. INTERFACE

Name: Interface

Intent:

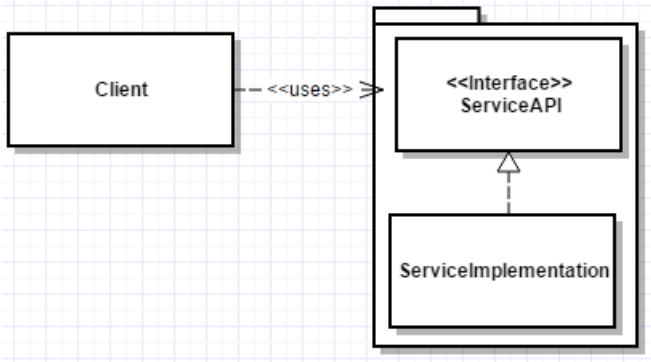
- Classes change messages between them
- The implementation must be switched at run time
- At design-time when the implementation used at compile time is not known

Definition

- Decouples the service from its clients

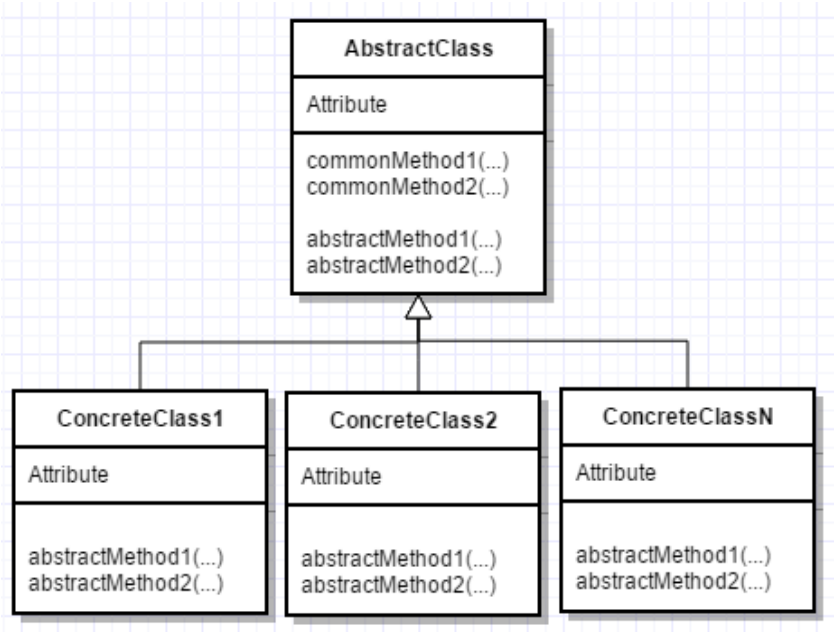
Consequences

- Programming to abstraction
- Easy change the service provider
- Transparency for client



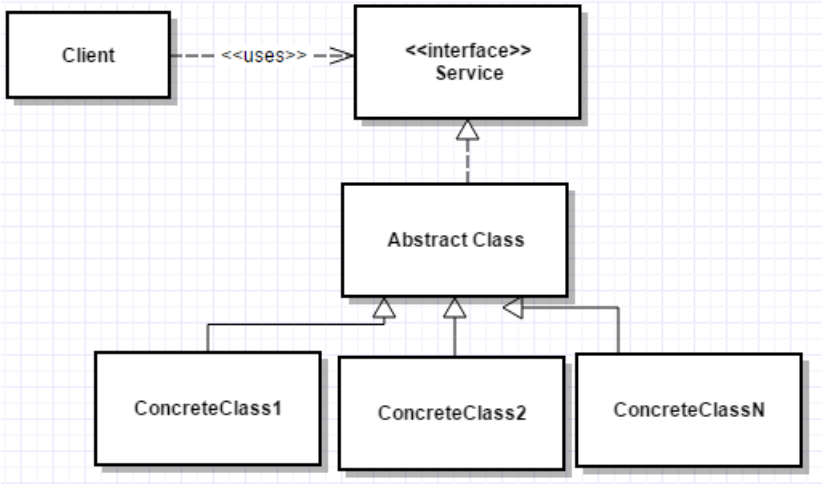
FUNDAMENTALS PATTERNS. ABSTRACT SUPERCLASS

- **Abstract superclass –ensures consistent behavior for its subclasses**
  - Consequences:
  - Common behavior is consistent over subclasses
  - Clients are using the abstract superclass



FUNDAMENTALS PATTERNS. INTERFACE AND ABSTRACT SUPERCLASS

- **Combines Interface and Abstract**
- **Superclass patterns**
  - Consequences:
  - Combines the advantages of both patterns
  - May provide a default behavior for the entire, or just a subset, of the Service interface via AbstractService class



FUNDAMENTALS PATTERNS. IMMUTABLE OBJECT

- **Immutable object – the internal state of the object doesn't change after its creation**
- **Consequences:**
  - Only constructors can change object's state
  - All member functions are constant functions (in C++)
  - Any member function that need to change the state will create a new instance
  - Increase design's robustness and maintainability
- **Example:**
  - String class in JDK

FUNDAMENTALS PATTERNS. IMMUTABLE OBJECT

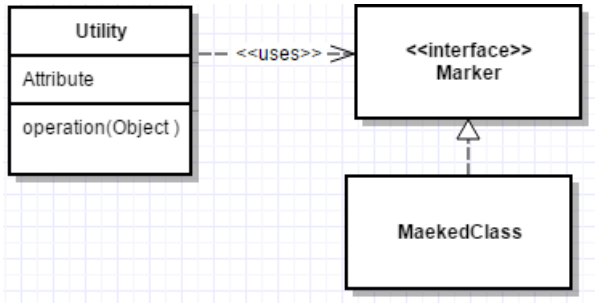
```
class Position {
    private int x;
    private int y;
   public Position(int x, int y) {
      this.x = x;
     this.y = y;
     } // Position(int, int)
    public int getX() { return x; }
   public int getY() { return y; }
   public Position offset(int xOffset, int yOffset) {
            return new Position(x+xOffset, y+yOffset);
    } // offset(int, int)
} // class Position
```

FUNDAMENTALS PATTERNS. MARKER INTERFACE

- **A class implements a marker interface in order to support a semantic attribute of the system**
- **Motivation**
  - unrelated concepts do have something in common
  - however, how to use this information is context-dependent
- **Consequences:**
  - Used by utility classes that need a specific behavior from their elements, without requesting a common base class
- **Example:**
  - Cloneable, Serializable, Remote in JDK

FUNDAMENTALS PATTERNS. MARKER INTERFACE

- Empty interfaces
- Are differences between marker interface in Java are annotations? (homework for next course)

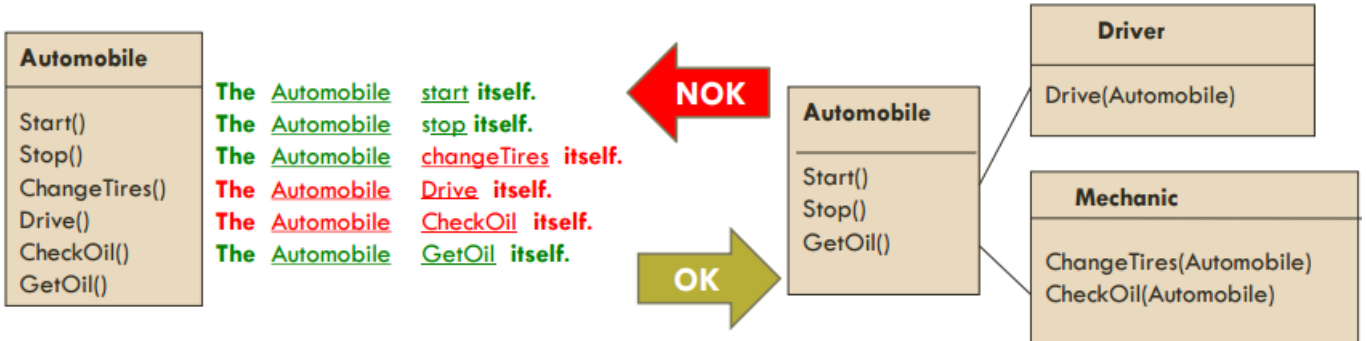


OBJECT ORIENTED DESIGN PRINCIPLES

- **OOD key principles**
  - collection of best practice, object-oriented design principles which can be applied to design, allowing you to accomplish various desirable goals such as loose-coupling, higher maintainability, intuitive location of interesting code, e.t.c.
- **Types**
  - SRP – Single Responsibility Principle
  - OCP - Open Close Principle
  - LSP – Liskov Substitution Principle
  - ISP – Interface Segmentation Principle
  - DIP – Dependency Inversion Principle
  - DRY – Don’t Repeat Yourself

SINGLE RESPONSABILITY PRINCIPLE

- SRP: Every object in your system should have a single responsibility, and all the object's services should be focused in carrying out that single responsibility.
- ONLY one reason to change something!
- Code will be simpler and easier to maintain.
- Example: Container and Iterator (Container manages objects; Iterator traverses the container)
- How to spot multiple responsibilities? Forming sentences ending in itself.



OPEN CLOSE PRINCIPLE

- OCP – Classes should be open for extension and closed for modification
- Allowing change, but without modifying existing code. It offers flexibility.
- Use inheritance to extend/change existing working code and don't touch working code.
- OCP can also be achieved using composition.

```
class Shape {
        int type;
        void  drawPolygon () { /* ... */ }
        void drawPoint () { /* ... */ }
    public:
        void draw();
};
void Shape::draw() {
       switch(type) {
          case POLYGON:
             drawPolygon (); break;
          case POINT:
             drawPoint ();  break;
       }
}
```

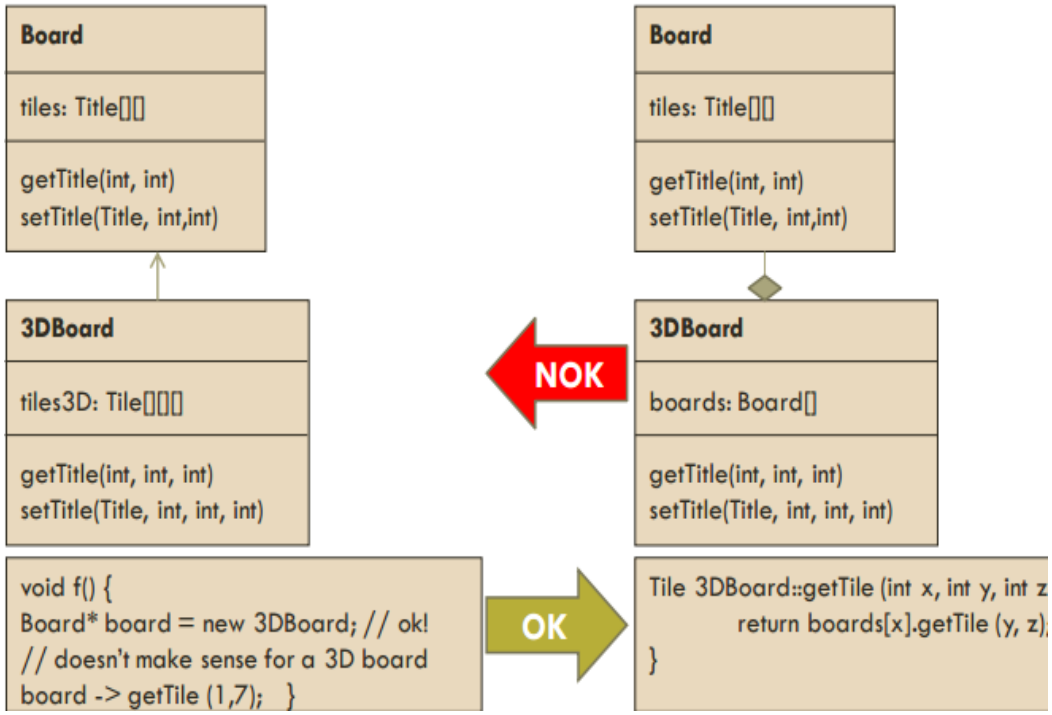
NOK

OK

```
class Shape {
    public:
        virtual void draw() = 0;
};

class Polygon : public Shape {
     public:
        void draw();
};

class Point : public Shape {
      public:
         void draw();
};

void Polygon::draw() { /* ...*/ }
void Point::draw() { /* ... */ }
```

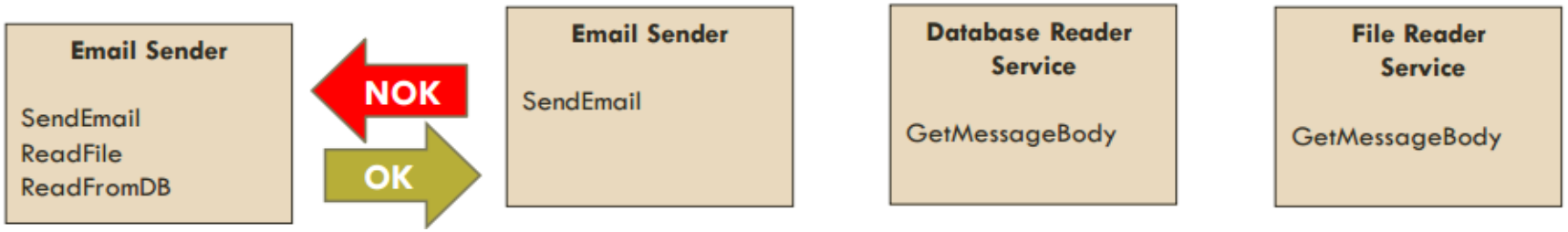
LISKOV SUBSTITUTION PRINCIPLE

- LSP: Subtypes must be substitutable for their base types.
- Well-designed class hierarchies
- Subtypes must be substitutable for their base class without things going wrong.



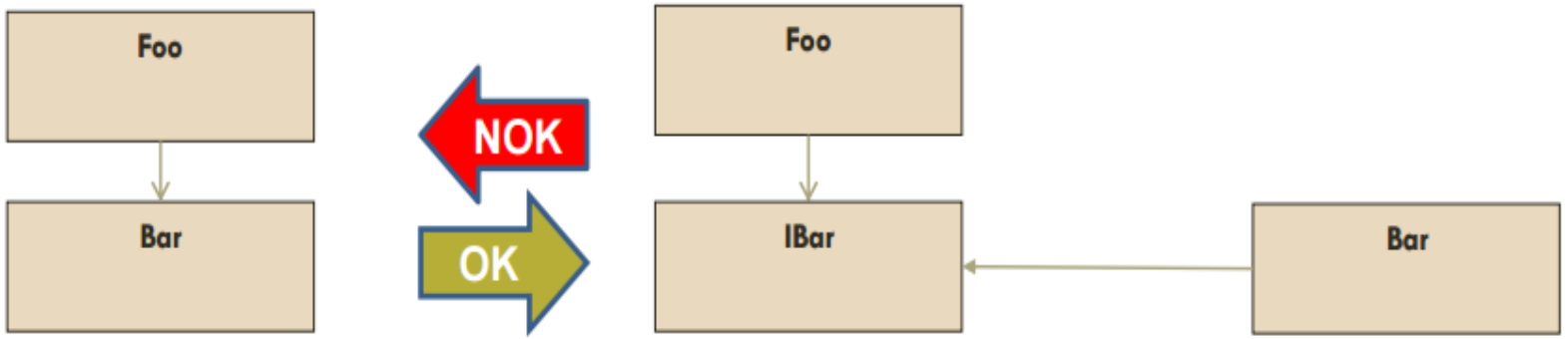
INTERFACE SEGMENTATION PRINCIPLE

- ISP: Clients should not be forced to depend on methods they do not use
- Keep interfaces small, cohesive, and focused
- Whenever possible, let the client define the interface



DEPENDENCY INVERSION PRINCIPLE

- High-level modules should not depend on low-level modules. Both should depend on abstractions
- Abstractions should not depend on details. Details should depend upon abstractions
- Detail should be dependent on Policy. This means that you should have the Policy define and own the abstraction that the detail implements.



DEPENDENCY INVERSION PRINCIPLE

```
//  Bad example


class Worker {
   public void work() {
       // ....working
   }
}

class Manager {
   Worker worker;

   public void setWorker(Worker w) {
        worker = w;
   }

   public void manage() {
      worker.work();
    }
}

class SuperWorker {
     public void work() {
       //.... working much more
    }
}
```

```
//  Good example


interface IWorker {
    public void work();
}

class Worker implements IWorker{
     public void work() {
        // ....working
     }
}

class SuperWorker implements IWorker{
     public void work() {
          //.... working much more
     }
}

class Manager {
   IWorker worker;

   public void setWorker(IWorker w) {
      worker = w;
   }

   public void manage() {
      worker.work();
    }
}
```

DON'T REPEAT YOURSELF

- DRY: Avoid duplicate code by abstracting out things that are common and placing those things in a single location.
- No duplicate code => ONE requirement n ONE place!
- This principle can and should be applied everywhere (e.g. in Analysis phase –don't duplicate requirements or features!)
- Code is easier and safer to maintain because we have to change only one place.