Software Design Patterns

Lecture 2

Software Design Principles

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Feature of Good Design (1)

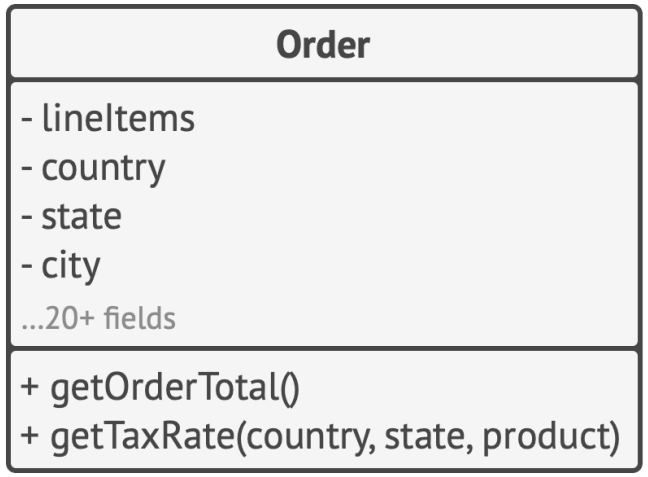
- **Code reuse**
  - **Challenge:** tight coupling between components, dependencies on concrete classes instead of interfaces, hardcoded operations
  - **Solution:** design patterns
    - However, sometimes making components more complicated
  - **Three levels of reuse**: a piece of wisdom from Erich Gamma
    - Lowest: classes
    - Highest: frameworks
    - **Middle level: design patterns**

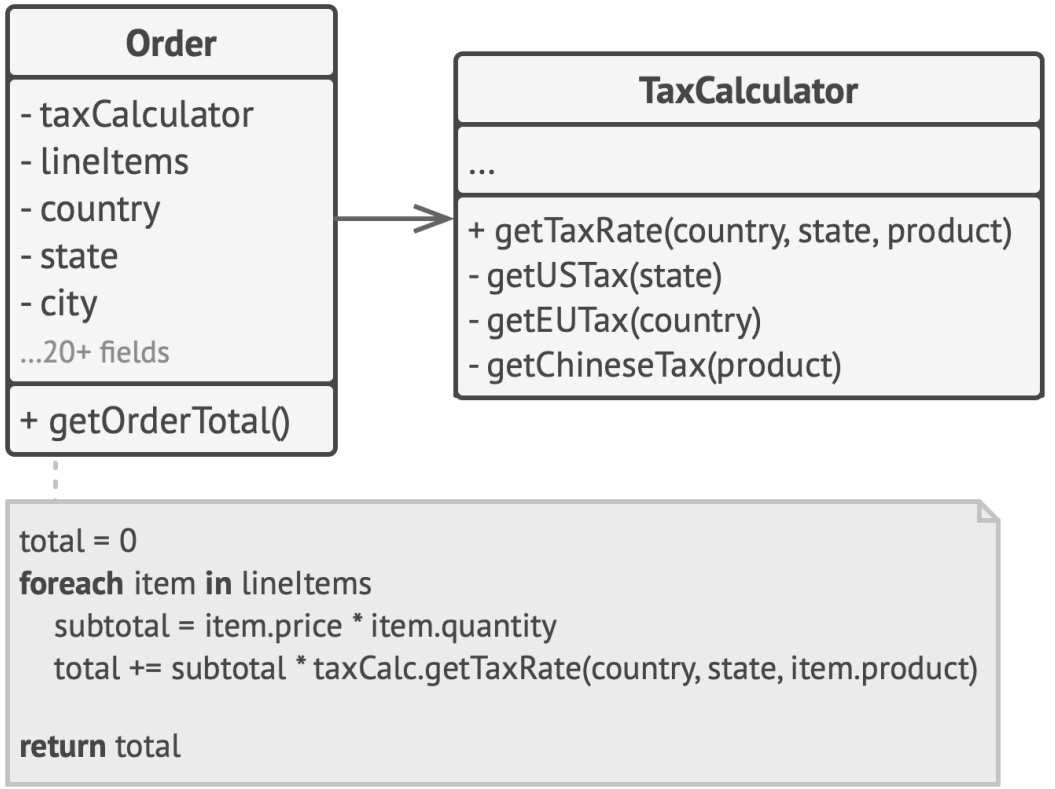
Feature of Good Design (2)

- **Extensibility**
  - **Change** is the only constant thing in a programmer's life
    - We understand the problem better once we start to solve it
    - Something beyond your control has changed
    - Objectives/requirements have changed
  - **Prepare for possible future changes** when designing an architecture

Good Design Principles (1)

- **Encapsulate what varies**
  - Identify the aspects that vary, and separate them from what stays the same
  - **Main goal: minimize the effect caused by changes**
  - Isolating program parts that vary in independent modules, protecting the rest
  - Encapsulation on a **method level**
  - Encapsulation on a **class level**





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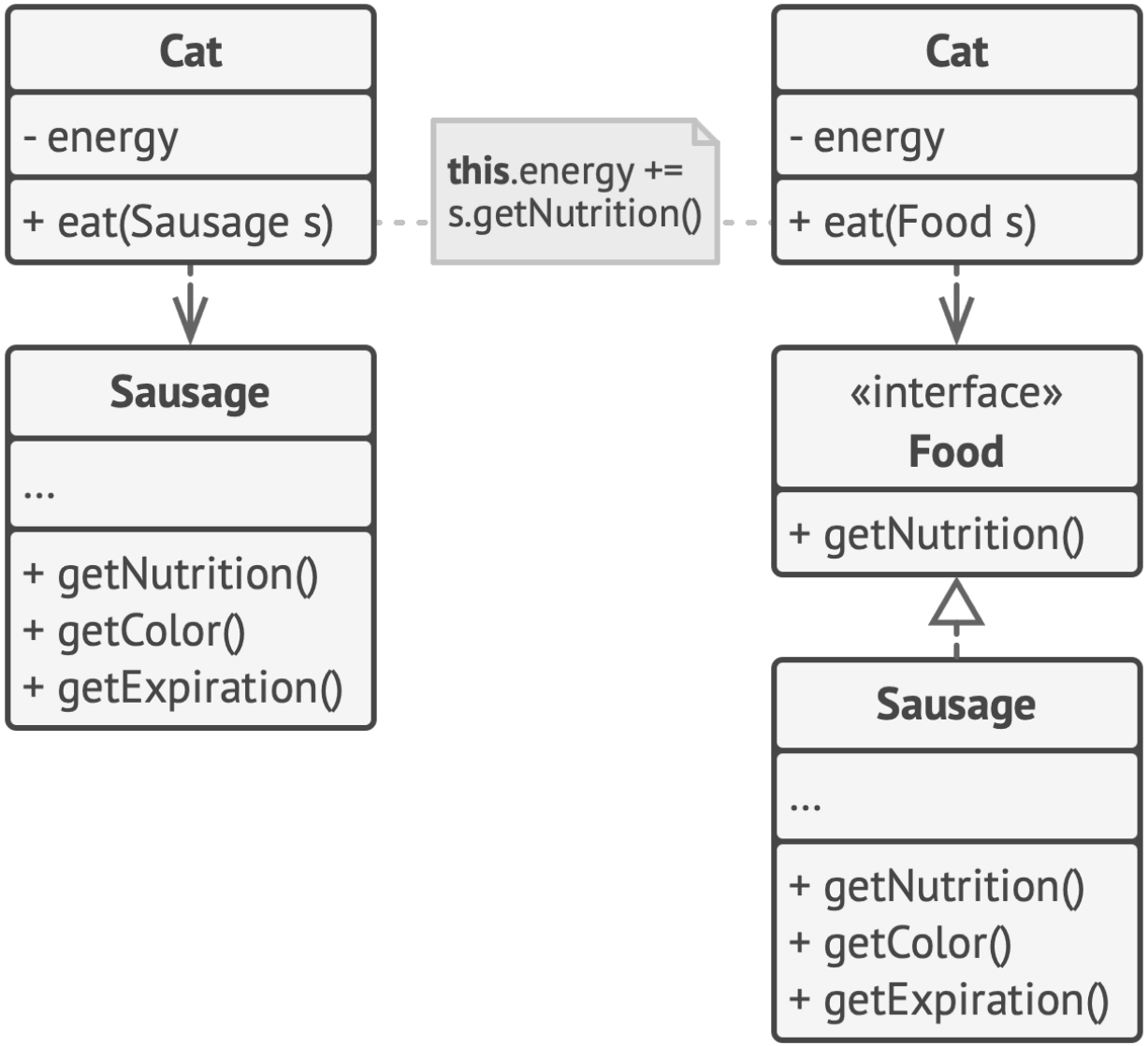
Good Design Principles (2)

- **Program to an interface, not an implementation**
  - In other words, **depend on abstractions**, not on concrete classes
  - The design is flexible enough if you can easily extend it **without breaking existing code**
  - **A possible approach**
    1. Determine **what exactly** one object needs from the other: which methods does it execute?
    2. Describe these methods in **a new interface or abstract class**.
    3. Make the class that is a dependency implement this interface.
    4. Make the second class dependent on this interface, rather than on the concrete class.

Good Design Principles (2) (cont.)

- **Example 1**



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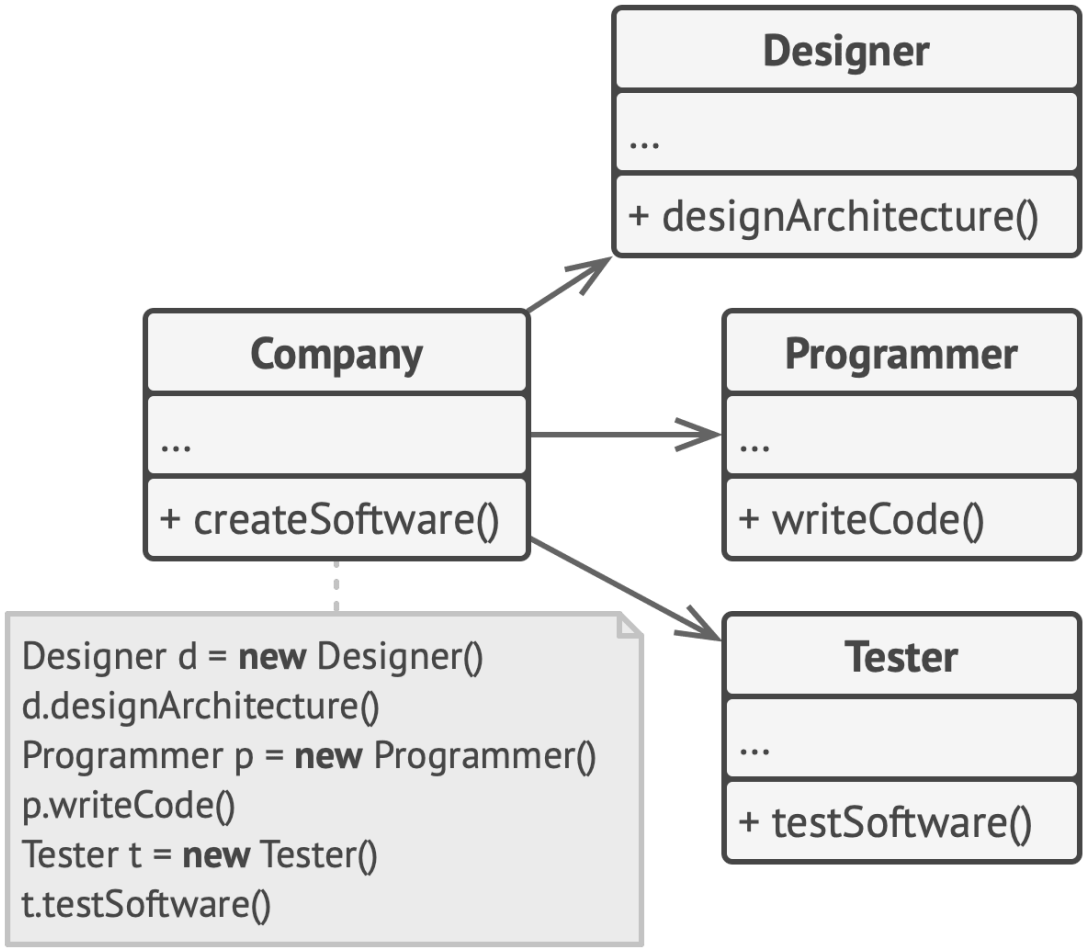
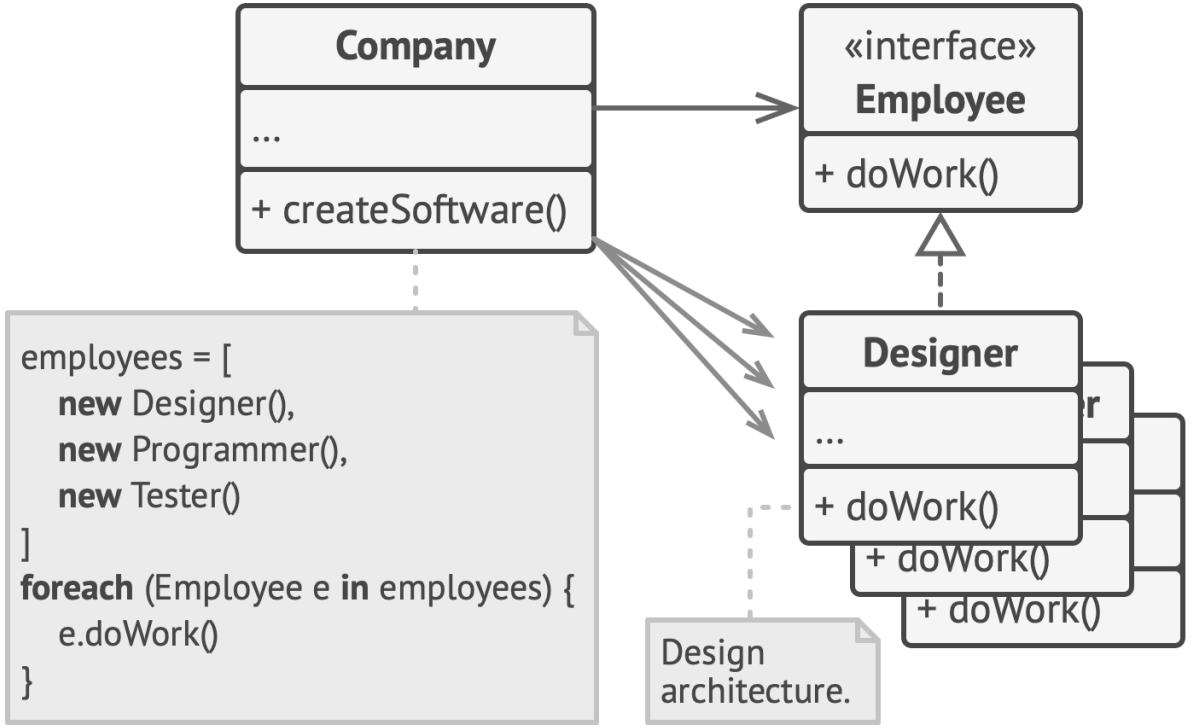
Good Design Principles (2) (cont.)

- **Example 2**





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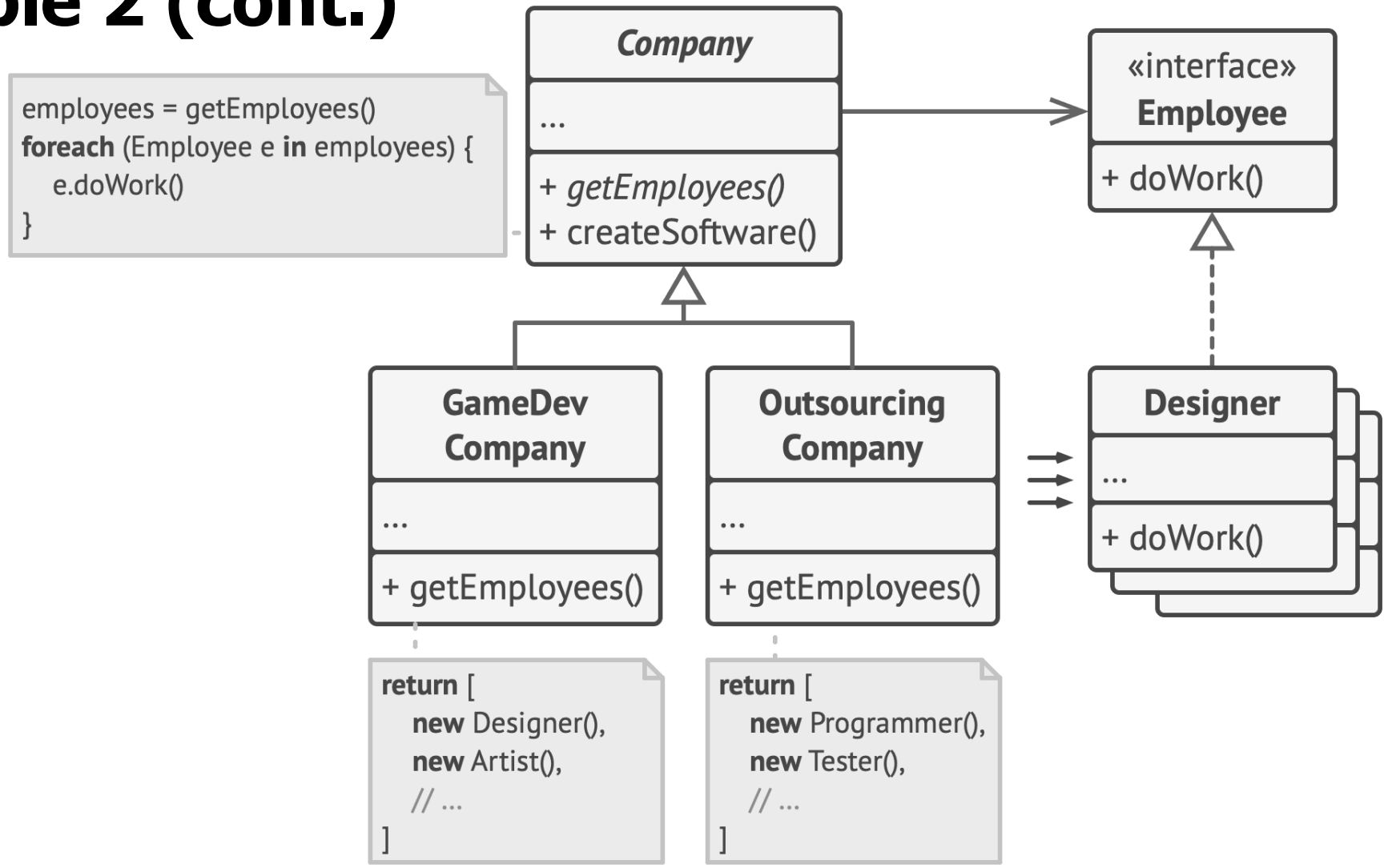
Good Design Principles (2) (cont.)

- **Example 2 (cont.)**



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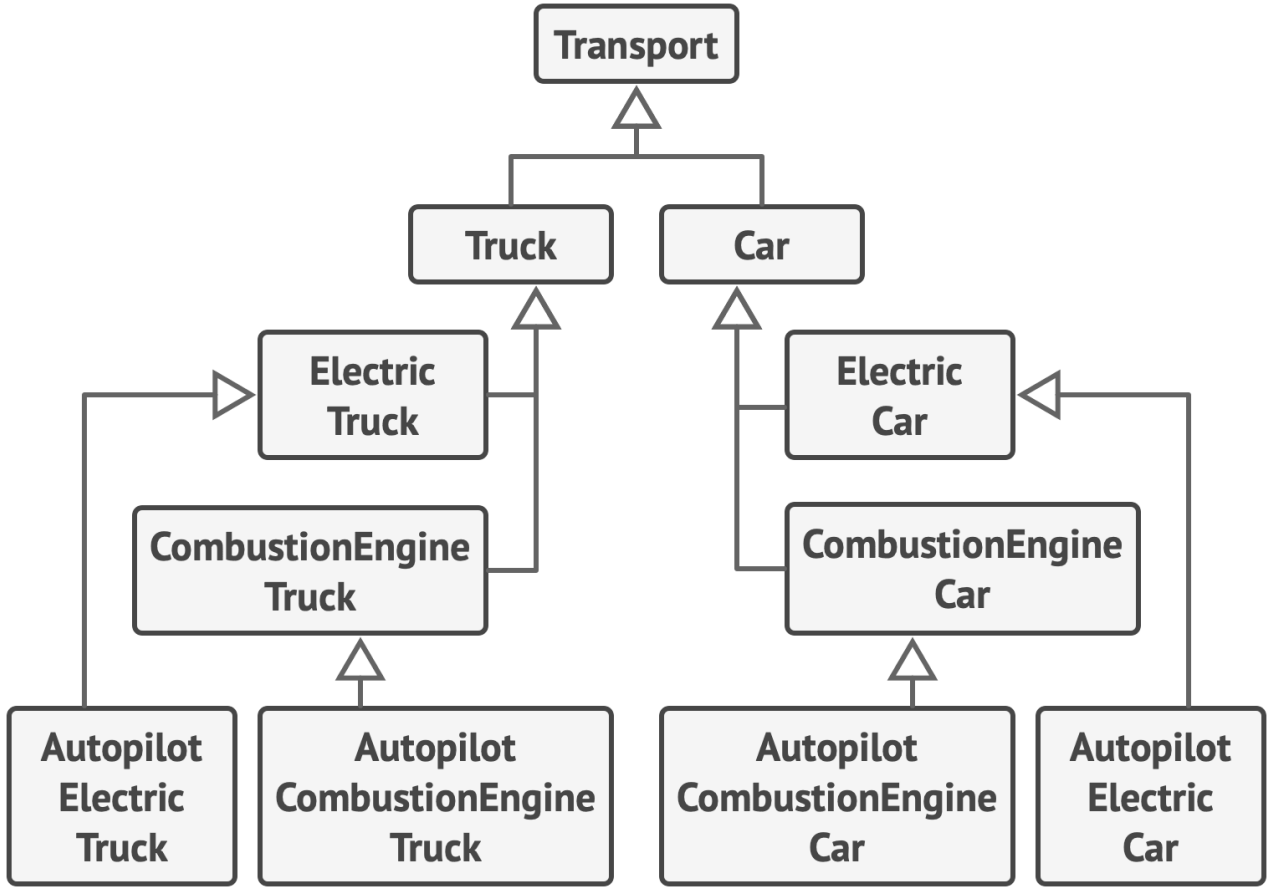
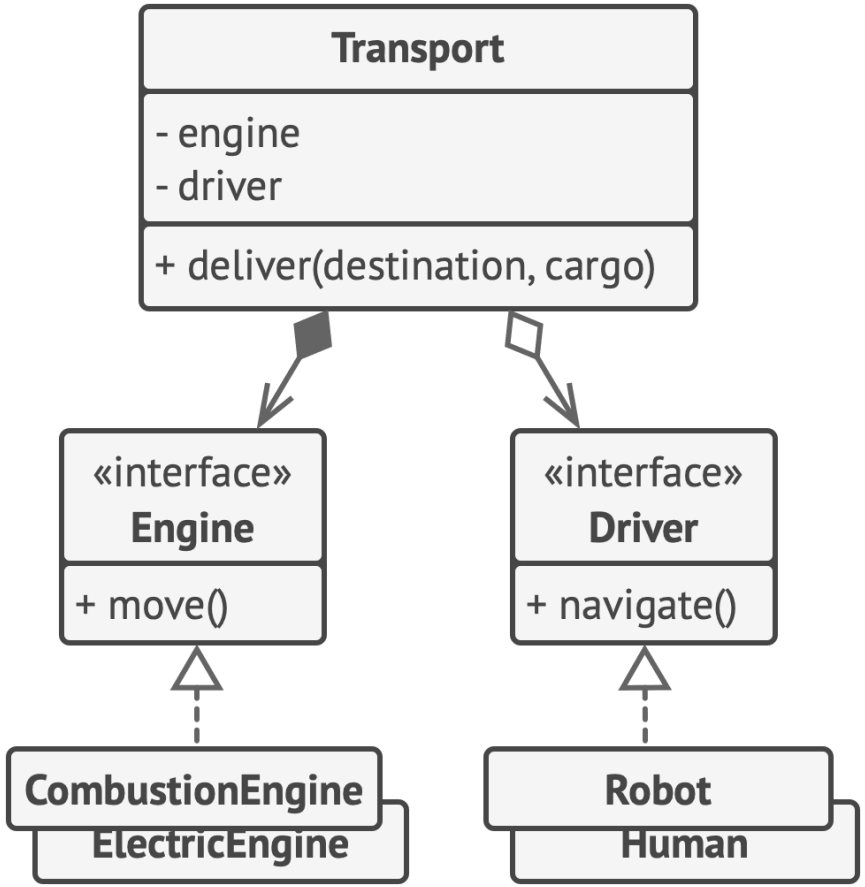
Good Design Principles (3)

- **Favor composition over inheritance**
  - **Challenge of inheritance**
    - A subclass cannot reduce the interface of the superclass
    - When overriding methods you need to make sure that the new behavior is compatible with the base one
    - Inheritance breaks encapsulation of the superclass
    - Subclasses are tightly coupled to superclasses
    - Trying to reuse code through inheritance can lead to creating parallel inheritance hierarchies

Good Design Principles (3) (cont.)

- **Inheritance vs. composition: "is a" vs. "has a"**





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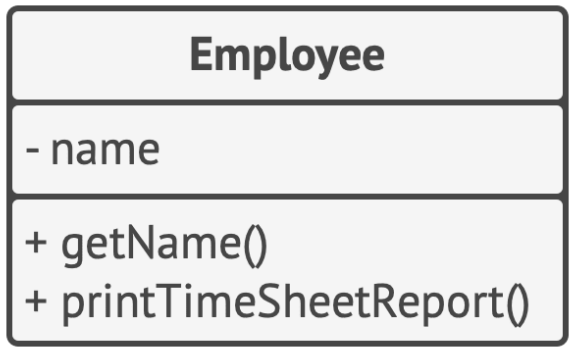
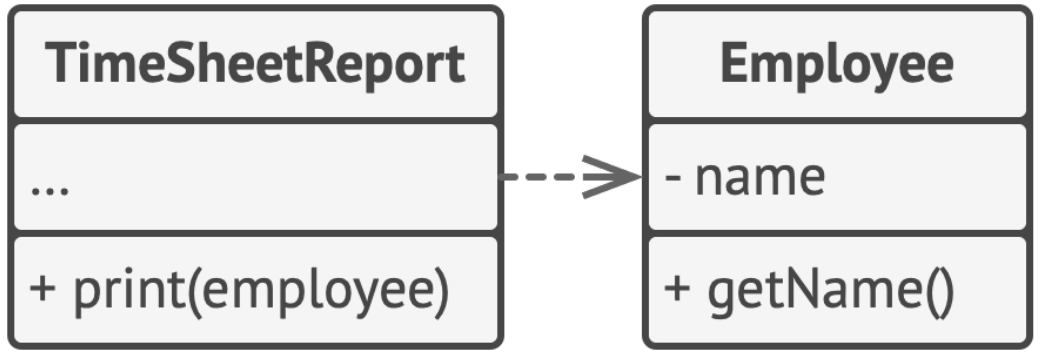
SOLID Principles

- **Agile Software Development: Principles, Patterns, and Practices**, by Robert Martin
- **Five design principles** intended to **make software designs more understandable, flexible and maintainable**
- However, using these principles mindlessly can cause more harm than good
  - **Always be pragmatic**

SOLID 1: Single Responsibility Principle

- A class should have **just one reason to change**
  - Try to make every class responsible for a single part of functionality, and make that responsibility entirely encapsulated
- Main goal: reducing complexity, and reducing risks





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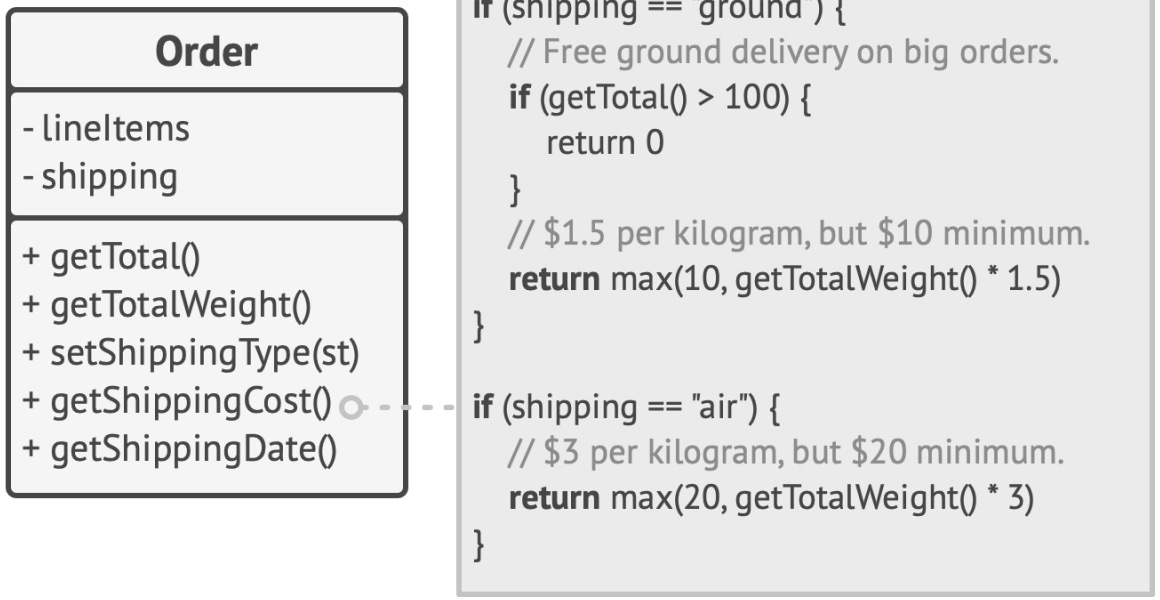
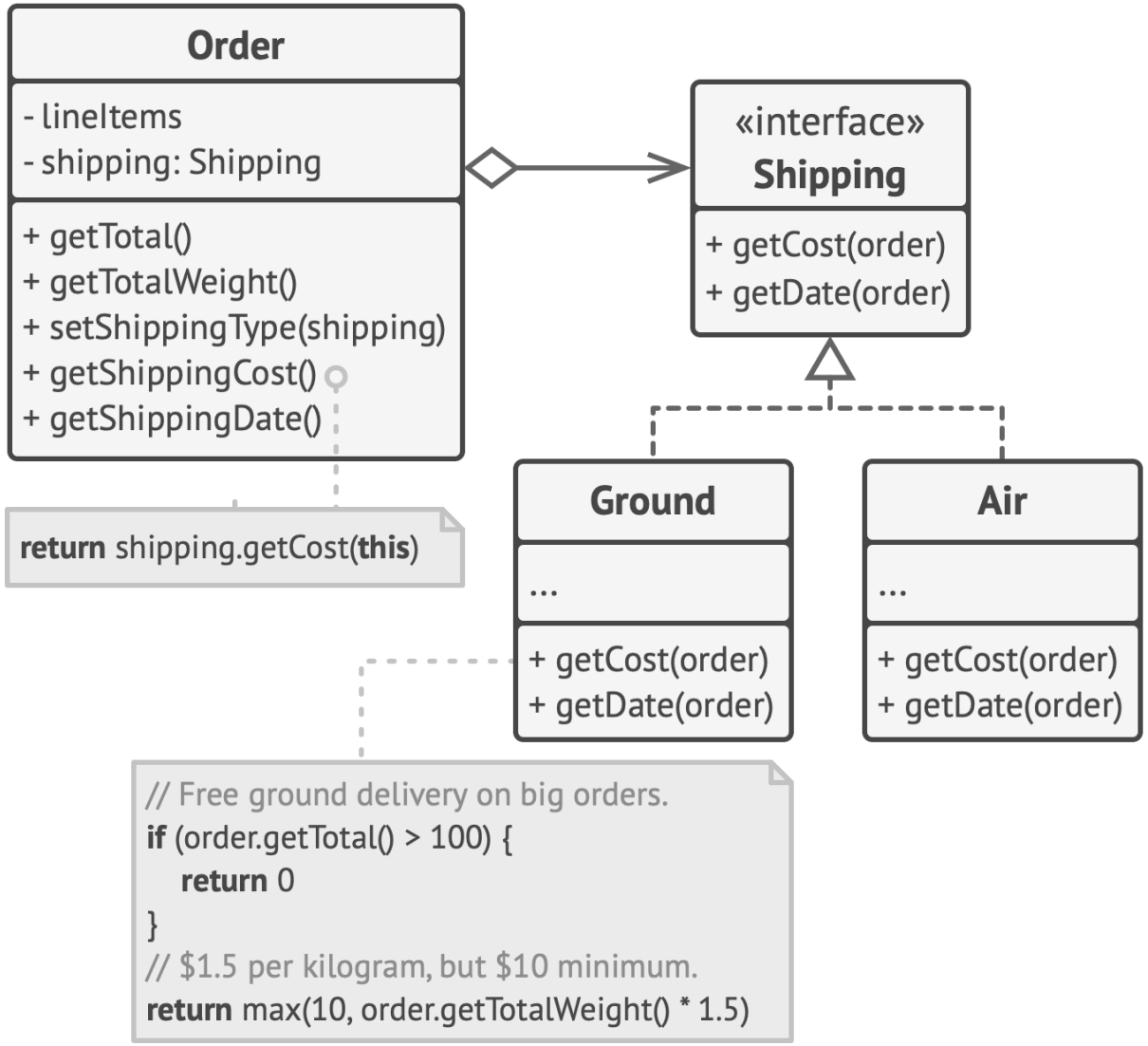
SOLID 2: Open/Closed Principle

- Classes should be **open for extension** but **closed for modification**
  - Keep existing code from breaking when implementing new features
- A class is **open** if it can be extended by subclasses
- A class is **closed** if it is 100% ready to be used by others
- A class can be both open (for extension) and closed (for modification) at the same time
  - Not necessary to be applied for all changes

SOLID 2: Open/Closed Principle (cont.)

- **Example**





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SOLID 3: Liskov Substitution Principle

- When extending a class, ensure the capability of **passing objects of the subclass in place of objects of the parent class without breaking the client code**
- The subclass should remain **compatible** with the behavior of the superclass
  - When overriding a method, extend the base behavior rather than replacing it with something else entirely
- Especially critical when developing libraries and frameworks
- **A set of checks**

SOLID 3: Liskov Substitution Principle (cont.)

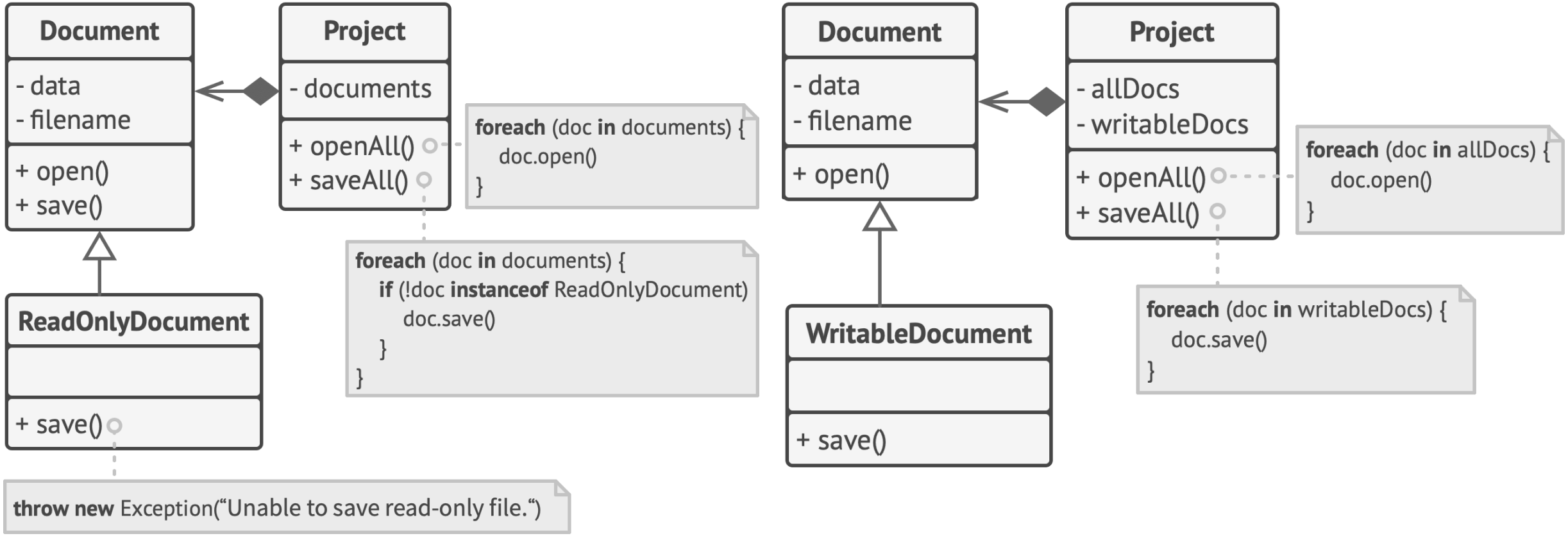
- (a) **Parameter types** in a method of a subclass should **match or be more abstract** than parameter types in the method of the superclass.
  - Example: **Base:** feed(Cat c) =>
    Good: feed(Animal c), **Bad:** feed(BengalCat c)
- (b) The **return type** in a method of a subclass should **match or be a subtype** of the return type in the method of the superclass.
  - Example: **Base:** adoptCat(): Cat =>
    Good: adoptCat(): BengalCat, **Bad:** adoptCat(): Animal
- (c) Types of **exceptions** should **match or be subtypes** of the ones that the base method is already able to throw.
  - Built into most modern programming languages

SOLID 3: Liskov Substitution Principle (cont.)

- (d) A subclass **shouldn't strengthen pre-conditions**.
  - Example: a method with an int parameter
- (e) A subclass **shouldn't weaken post-conditions**.
  - Example: a method working with a database
- (f) **Invariants** of a superclass **must be preserved** (least formal rule of all)
  - Invariants: conditions in which an object makes sense
  - **Safest way** to extend a class: introduce new fields and methods
- (g) A subclass **shouldn't change values of private fields** of the superclass.

SOLID 3: Liskov Substitution Principle (cont.)

- **Example**



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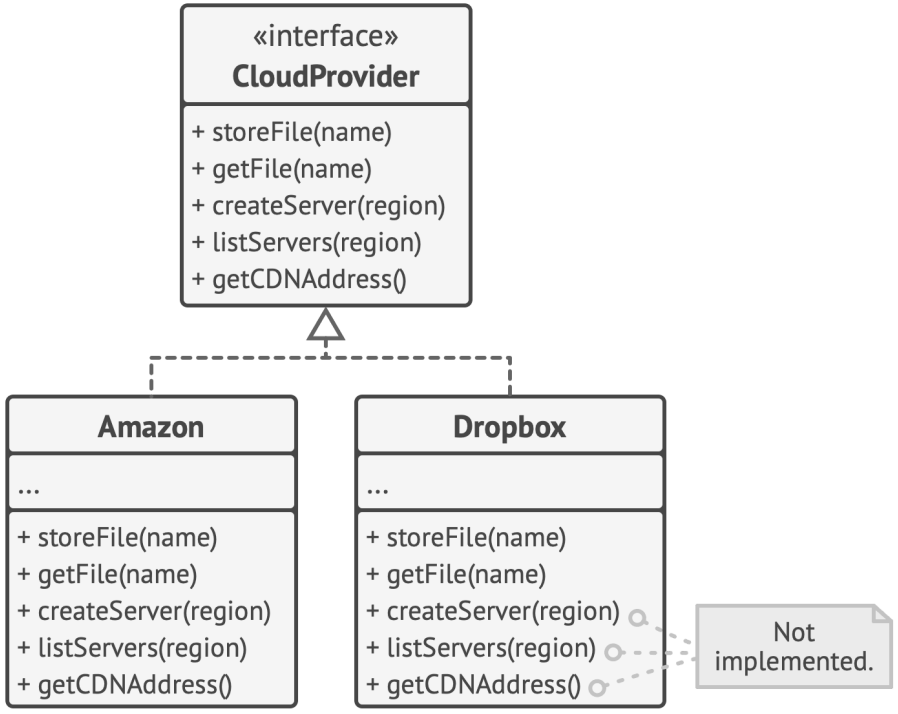
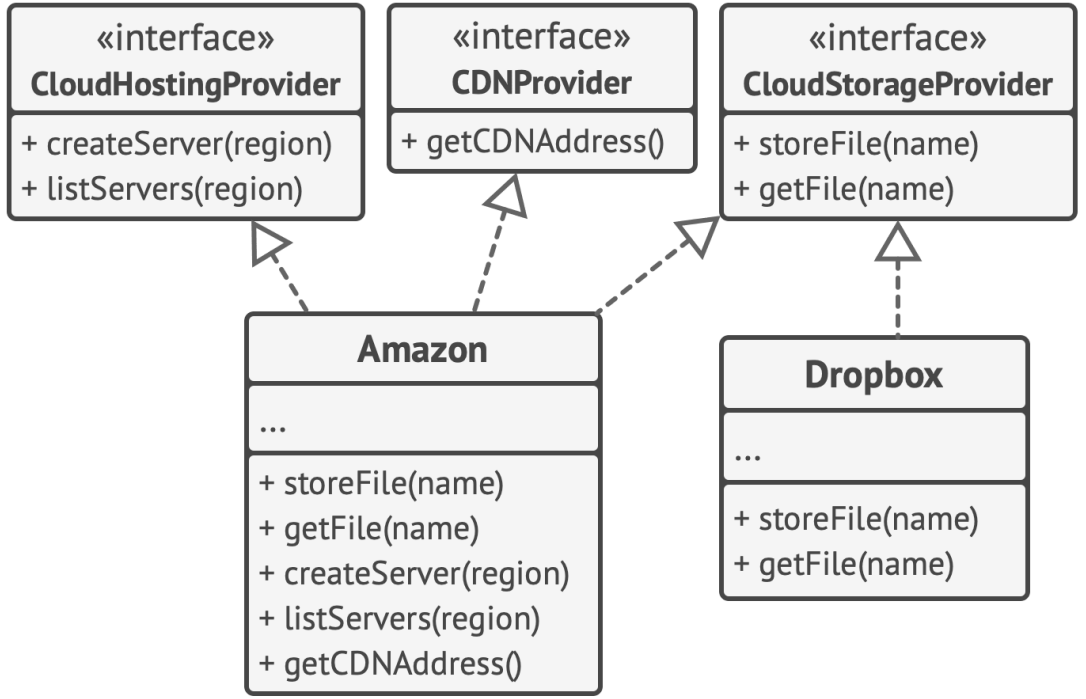
SOLID 4: Interface Segregation Principle

- Clients **shouldn't be forced to depend on methods they do not use**
  - Make interfaces **narrow enough** that client classes don't have to implement behaviors they don't need
  - **Break down** "fat" interfaces into more granular and specific ones





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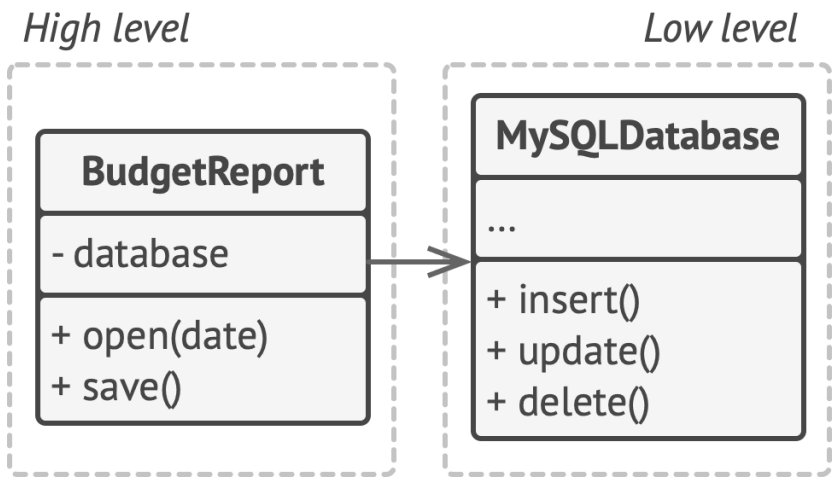
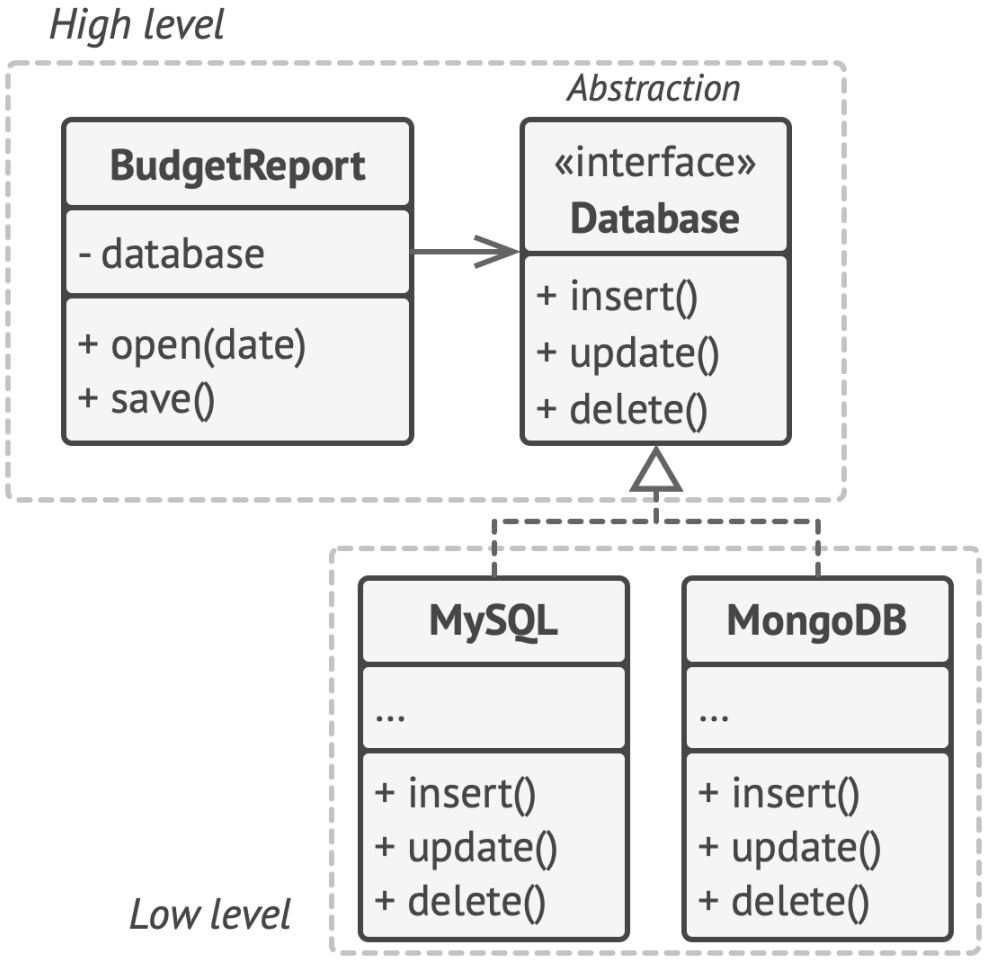
SOLID 5: Dependency Inversion Principle

- **High-level classes shouldn't depend on low-level classes, and both should depend on abstractions**
- Low-level classes vs. high-level classes
- Problem: business logic classes tend to become dependent on primitive low-level classes
- **Suggestion: changing the direction of dependency**
- **Approach**
  1. Describe interfaces for low-level operations that high-level classes rely on, preferably in business terms
  2. Make high-level classes dependent on the interfaces, resulting in a softer dependency
  3. Low-level classes implement the interfaces, dependent on the business logic level

SOLID 5: Dependency Inversion Principle (cont.)

- **Example**





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