# CS427a: Object-Oriented Programming

## Design Patterns for Flexible and Reusable design

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(from slides by Y. Richard Yang)

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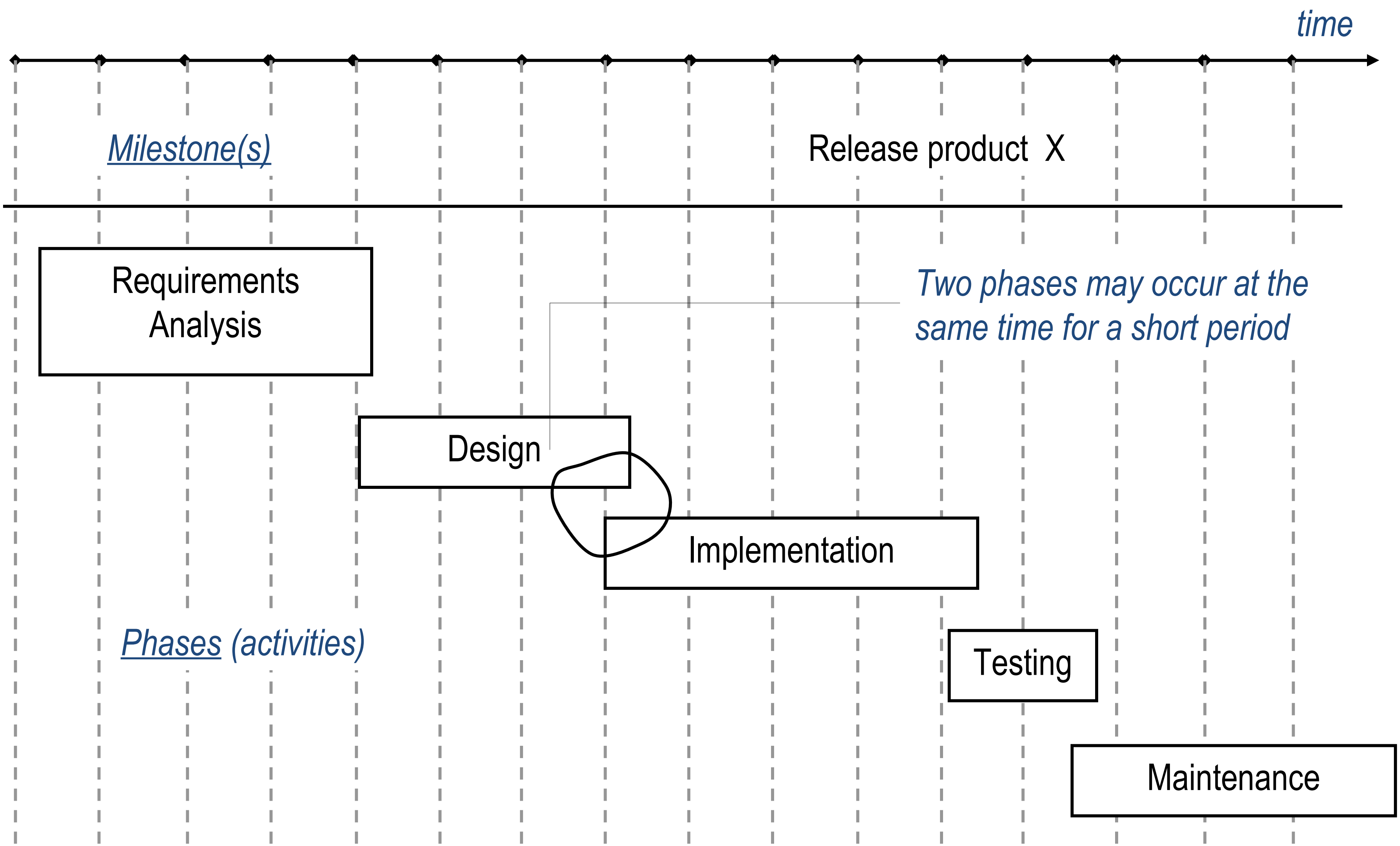
# Reusability, Flexibility, and Maintainability

- One thing constant in software development is CHANGE
- For software that is used over a period of years, the cost of keeping it current in the face of changing needs often exceeds the cost of originally developing it.
- A key need in software design is the ability for maintenance and modification to keep abreast of changes.

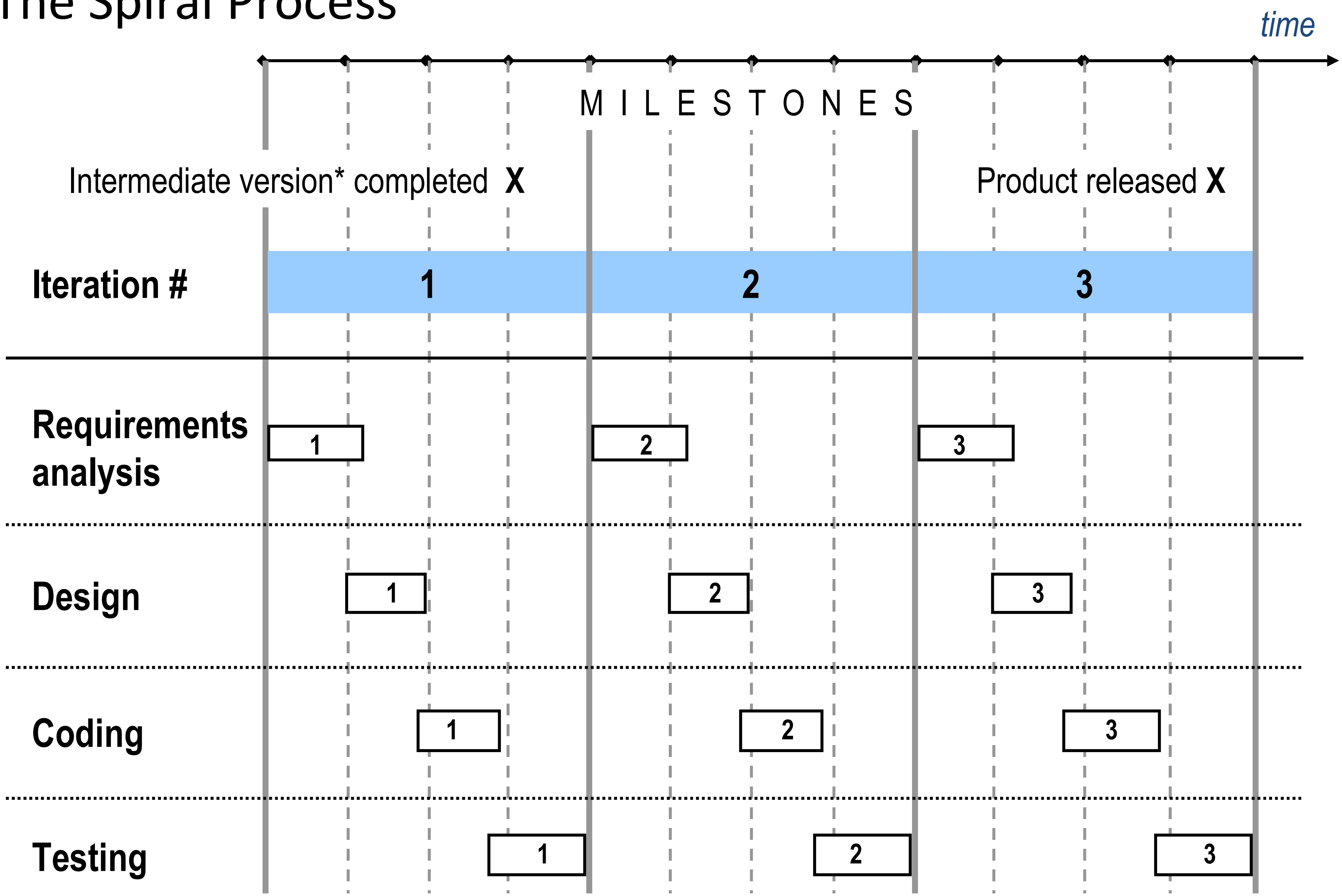
# The Waterfall Software Process



# Why a Pure Waterfall Process is Usually Not Practical

- *Don’t know up front everything wanted and needed*
  - Usually hard to visualize every detail in advance
- To gain confidence in an estimate, we need to design and actually implement parts, especially the riskiest ones, this may probably lead to modify requirements as a result
- *We often need to execute intermediate builds*
  - Stakeholders need to gain confidence
  - Designers and developers need confirmation they're building what’s needed and wanted
- *Team members can't be idle while the requirements are being completed*

# The Spiral Process




*typically a prototype

Adapted from *Software Design: From Programming to Architecture* by Eric J. Braude (Wiley 2003), with permission.

# Advantage of OO Design

OO systems exhibit recurring structures that promote

- Abstraction
- Modularity
- Flexibility
- Extensibility
- Elegance

# Aspect of Reusability

- *Classes – in source code form*
  – Thus, we write *generic code* whenever possible
- *Assemblies of related classes*
  - A *toolkit* is a library of reusable classes designed to provide useful, general-purpose functionality.
    - E.g., C++ standard library, Boost
  - An *application framework* is a specific set of classes that cooperate closely with each other and together embody a reusable design for a category of problems.
    - E.g., Java APIs (`Applet`, `Thread`, etc), gtkmm
- Design pattern

# Making a Class Re-usable

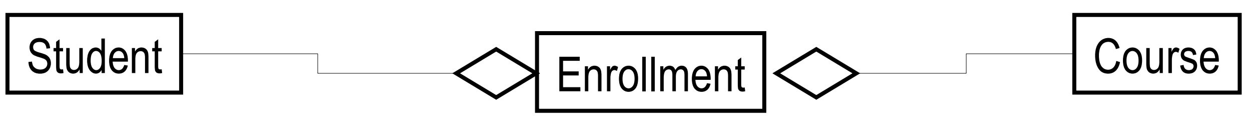
- Define a useful abstraction
  - attain broad applicability
- Reduce dependencies on other classes

…

# Reducing Dependency Among Classes

Replace …


with …



# Aspect of Flexibility

- Making small variation to existing functionality

- Adding new kinds of functionality

- Changing functionality

# Some Techniques to Achieve Flexibility

| Flexibility Aspect: ability to … | Some techniques |
|---|---|
| … create objects in variable configurations determined at runtime | "Creational" design patterns |
| … create variable trees of objects or other structures at runtime | "Structural" design patterns |
| … change, recombine, or otherwise capture the mutual behavior of a set of objects | "Behavioral" design patterns |
| … create and store a possibly complex object of a class. | Component |
| … configure objects of predefined complex classes – or sets of classes – so as to interact in many ways | Component |

# Roadmap

- We will focus on flexibility and reusability
  - It is important to remember that real systems also need to consider efficiency and robustness
- We will start with design patterns, and then look into the design of some OO libraries/toolkit/framework
- We will learn by examples:
  - *Example* is not another way to teach, it is the *only* way to teach. -- *Albert Einstein*

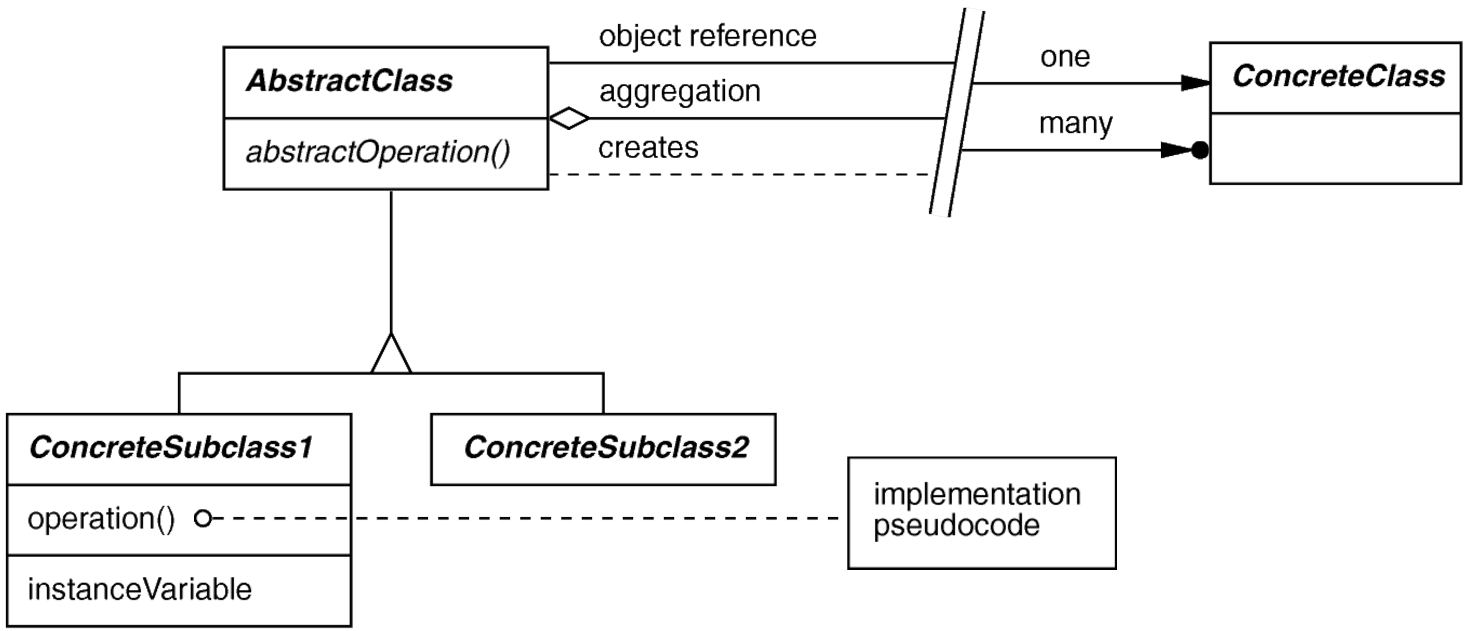
# What is a Design Pattern

- Abstracts a recurring design structure
- Comprises class and/or object
  - dependencies
  - structures
  - interactions
  - conventions

- Distills design experience
- Names & specifies the design structure explicitly

- Language- & implementation-independent
  - A “micro-architecture”

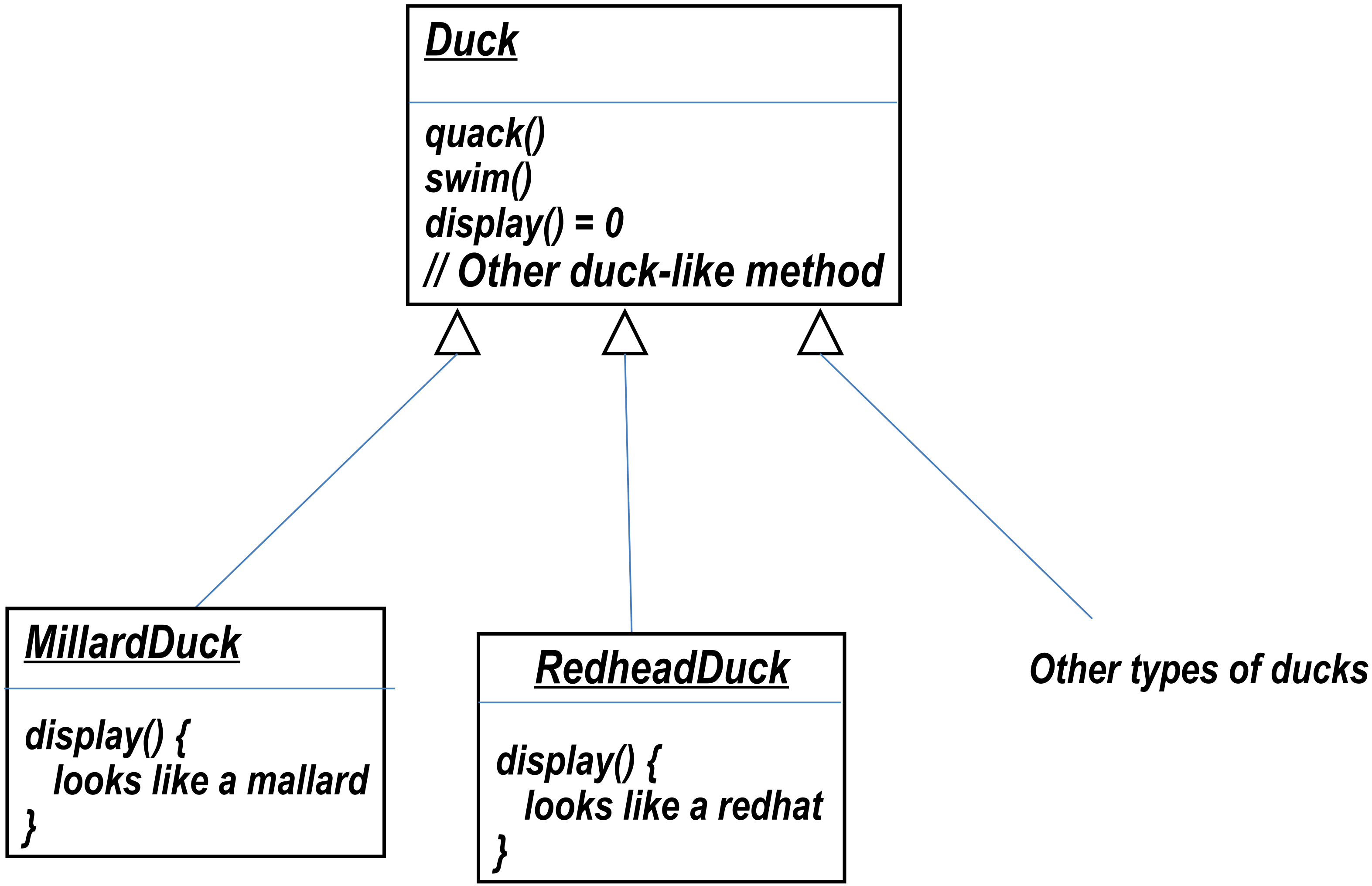
# UML/OMT Notation



# Example: Duck Game

- A startup produces a duck-pond simulation game
- The game shows a large variety of duck species swimming and making quacking sounds

# Initial Design



# Design Change: add fly()


***Duck***

*quack()*
*swim()*
*display() = 0*
*fly()*
*// Other duck-like method*

***MillardDuck***

*display() {*
*looks like a mallard*
*}*

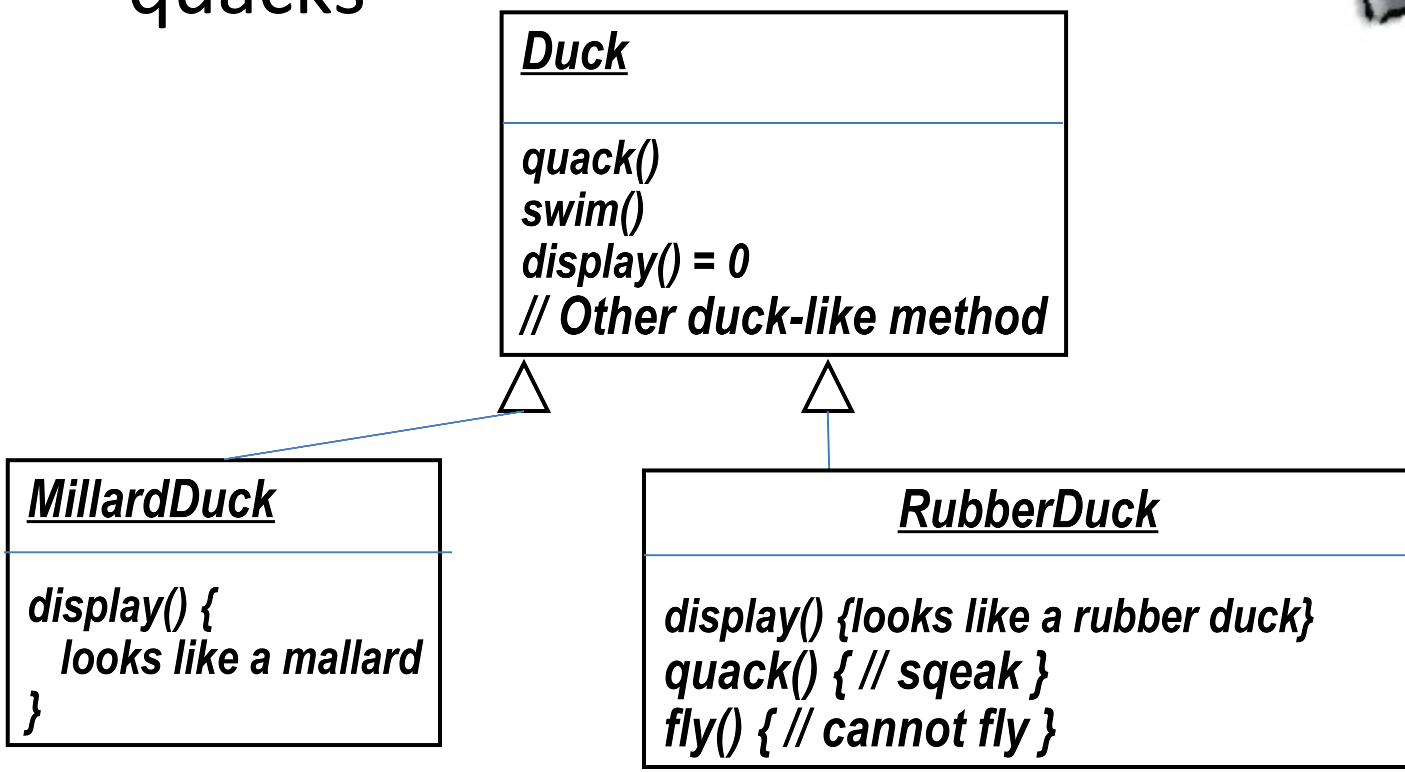
***RedheadDuck***

*display() {*
*looks like a redhat*
*}*

*Other types of ducks*

# Problem

- Generalization may lead to unintended behaviors:
  a rubber duck is flying and quacks



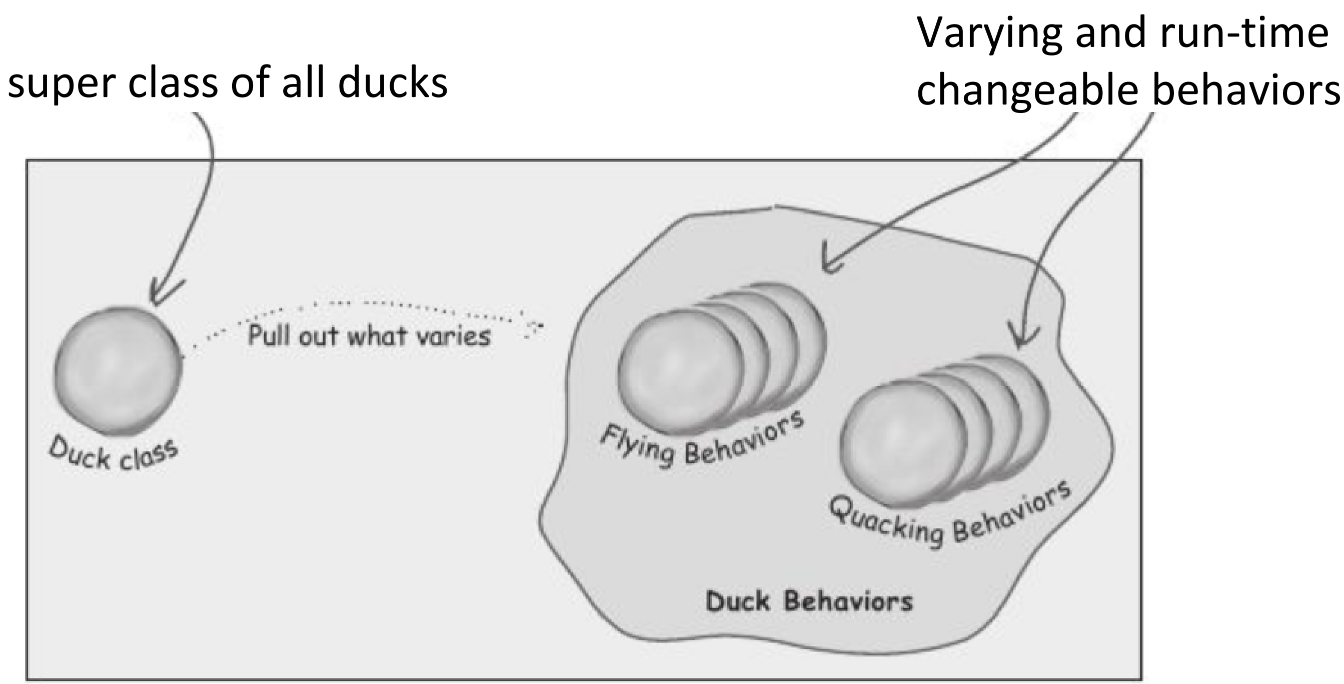
# Anticipating Changes

- Identify the aspects of your application that may vary
  - What may change?

- Anticipate that
  - new types of ducks may appear and
  - behaviors (quack, swimming, and flying) may change, even change at run time (swirl flying, circular flying, …)

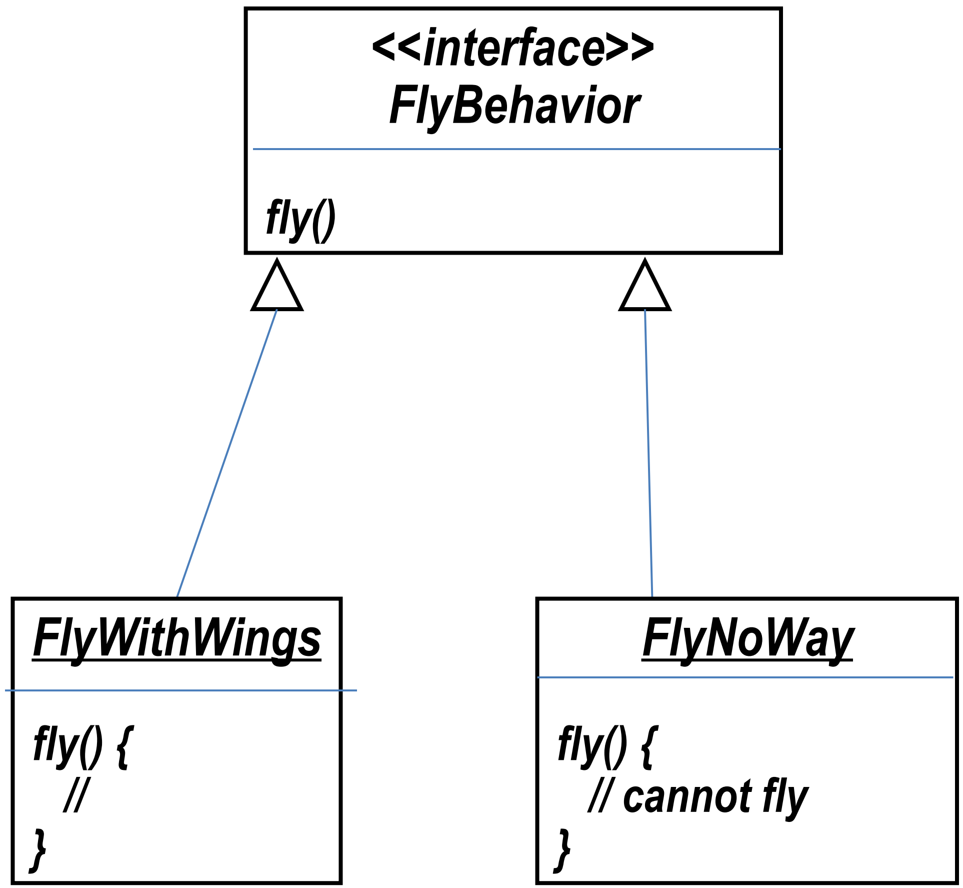
# Handling Varying Behaviors

- Solution: take what varies and “encapsulate” it
  - Since fly() and quack() vary across ducks, separate these behaviors from the Duck class and create a new set of classes to represent each behavior



# Design

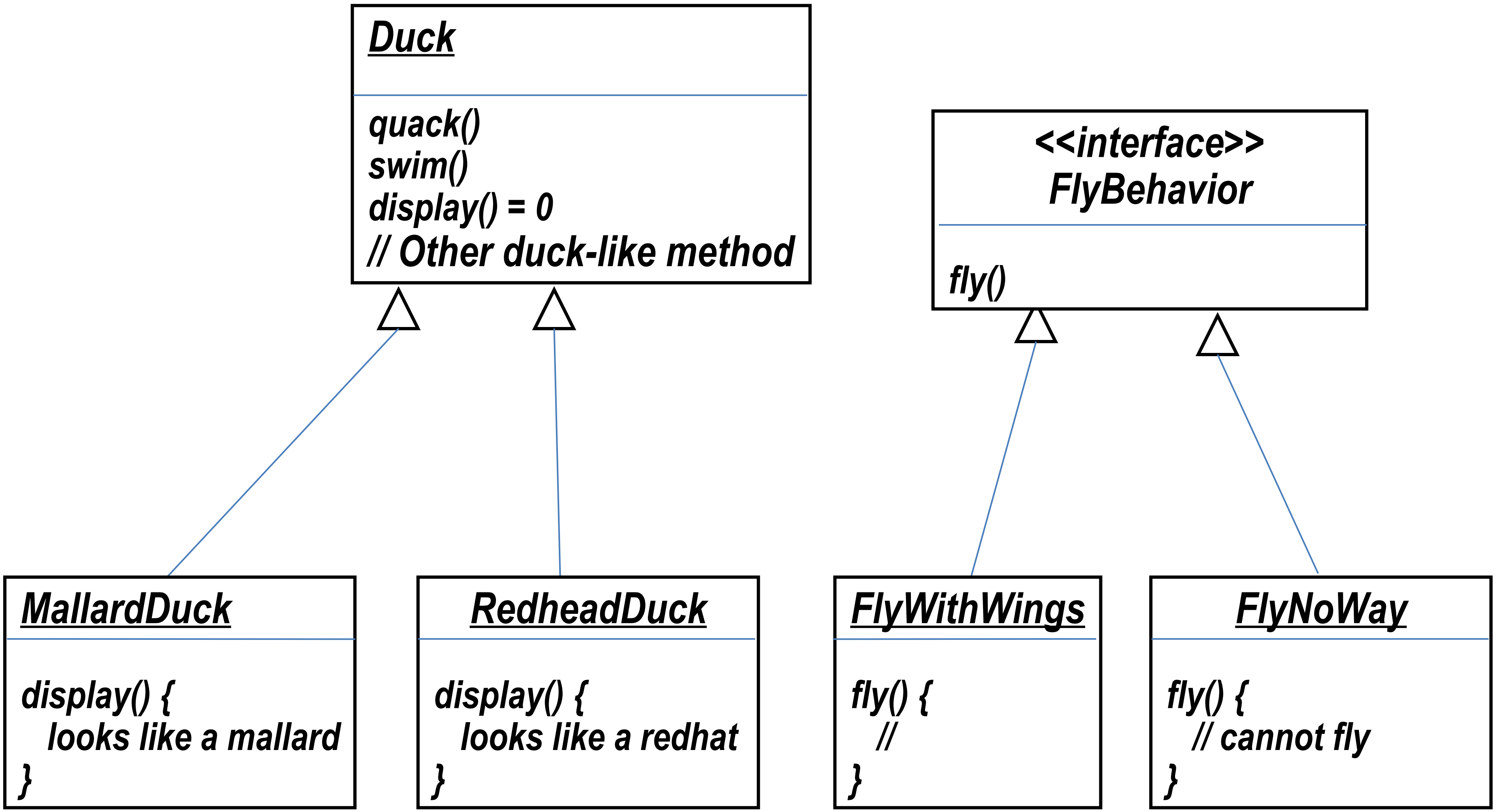
- Each duck object has a fly behavior



# Programming to implementation vs. interface/supertype

- Programming to an implementation
  - Dog d = new Dog();
  - d.bark();
- Programming to an interface/supertype
  - Animal a = new Dog();
  - a.makeSound();

# Implementation



# Exercise

- Add rocket-powered flying?

# The Strategy Pattern

- Defines a set of algorithms, encapsulates each one, and makes them interchangeable by defining a common interface

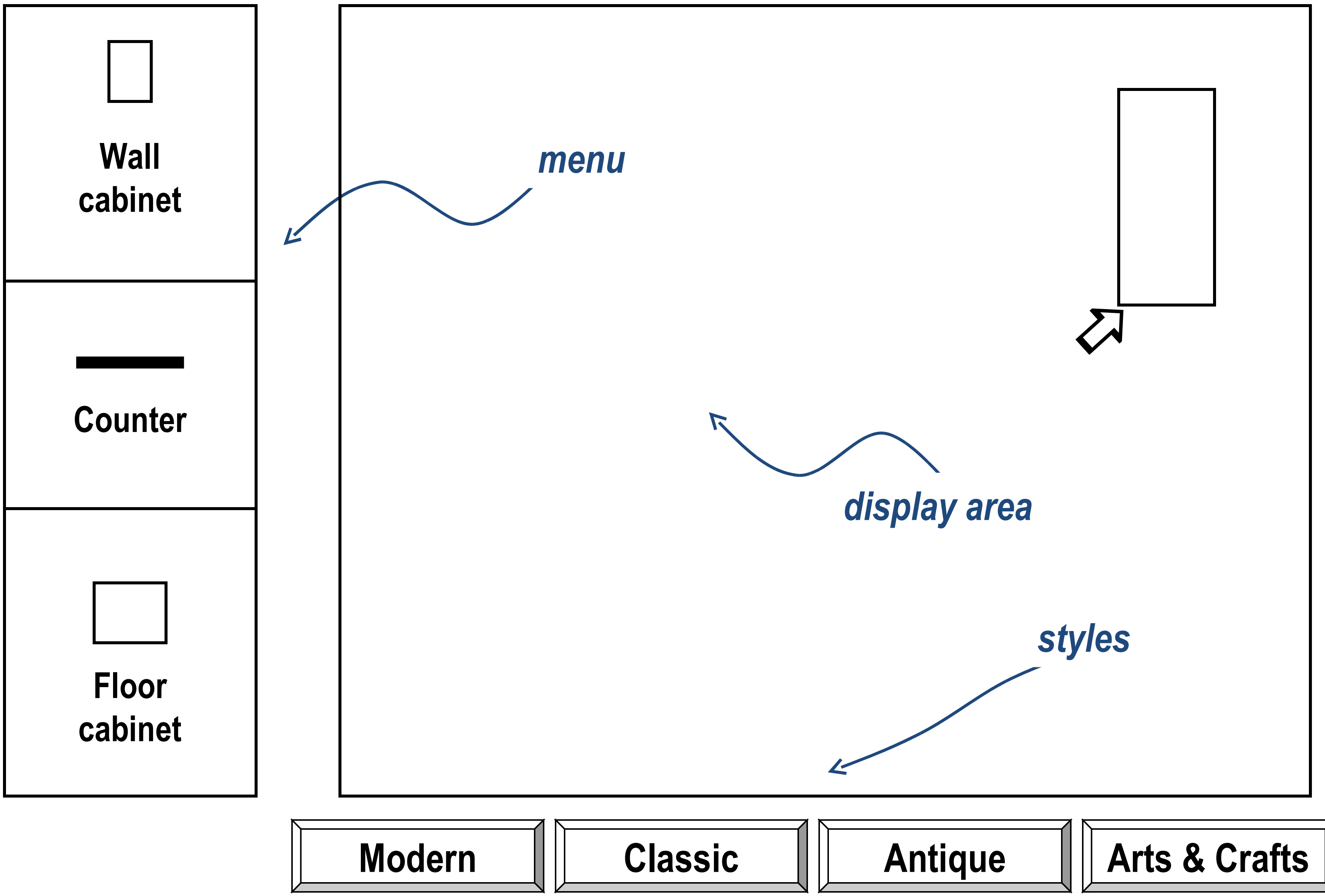
# Exercise


Character
WeaponBehavior weapon;
fight();
KnifeBehavior
useWeapon() { // implements cutting
with a knife }
BowAndArrowBehavior
useWeapon() { // implements shoot-
with a bow }
Queen
fight() { ... }
<<interface>>
WeaponBehavior
useWeapon();
King
fight() { ... }
Troll
fight() { ... }
AxeBehavior
useWeapon() { // implements chop-
ping with an axe }
Knight
fight() { ... }
SwordBehavior
useWeapon() { // implements swing-
ing a sword }
setWeapon(WeaponBehavior w) {
this.weapon = w;
}

# Summary: Design Principles

- Identify the aspects of your application that vary and separate them from what stay the same
- Program to an interface not implementation
- Favor composition over inheritance

# *Example: KitchenViewer* Interface

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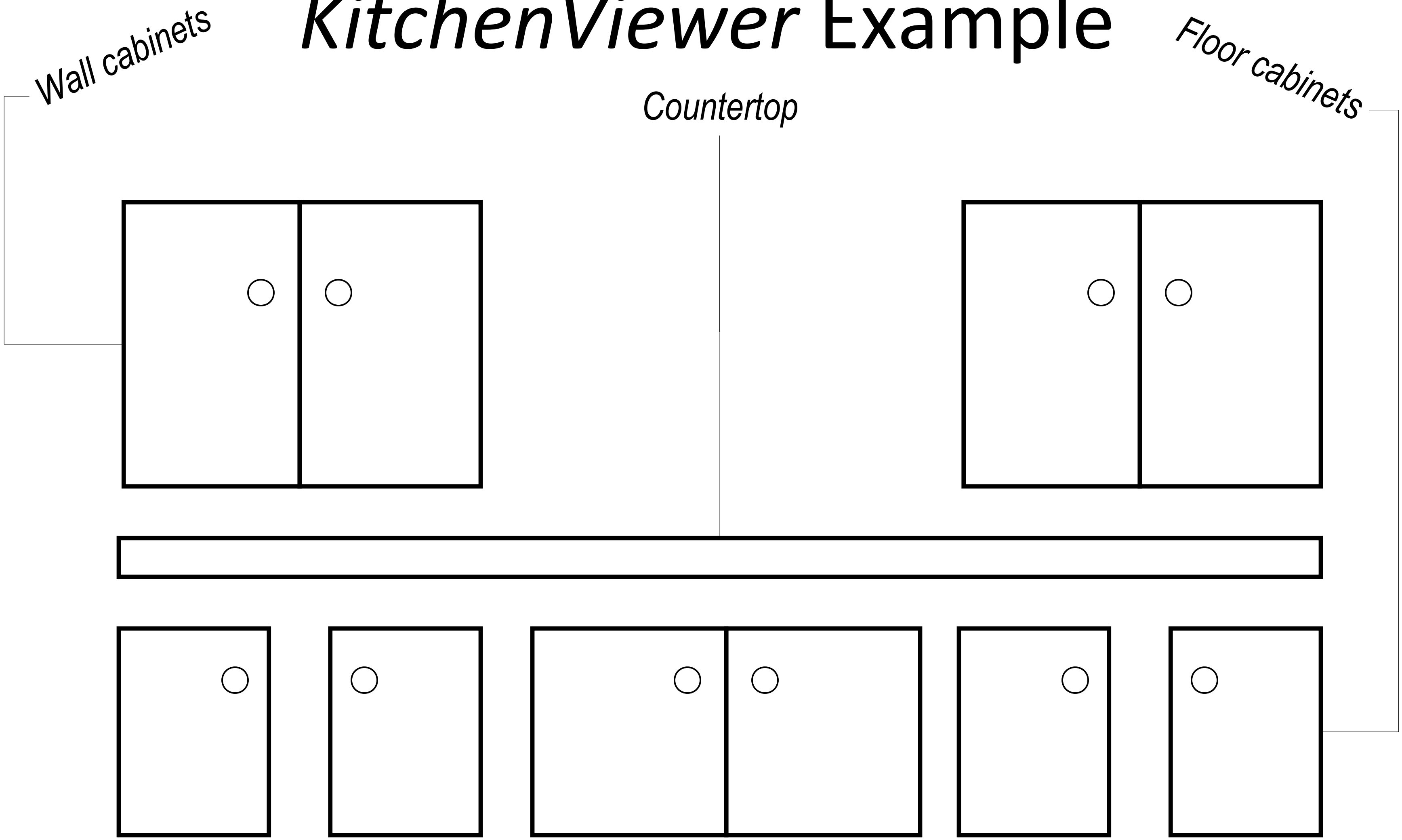
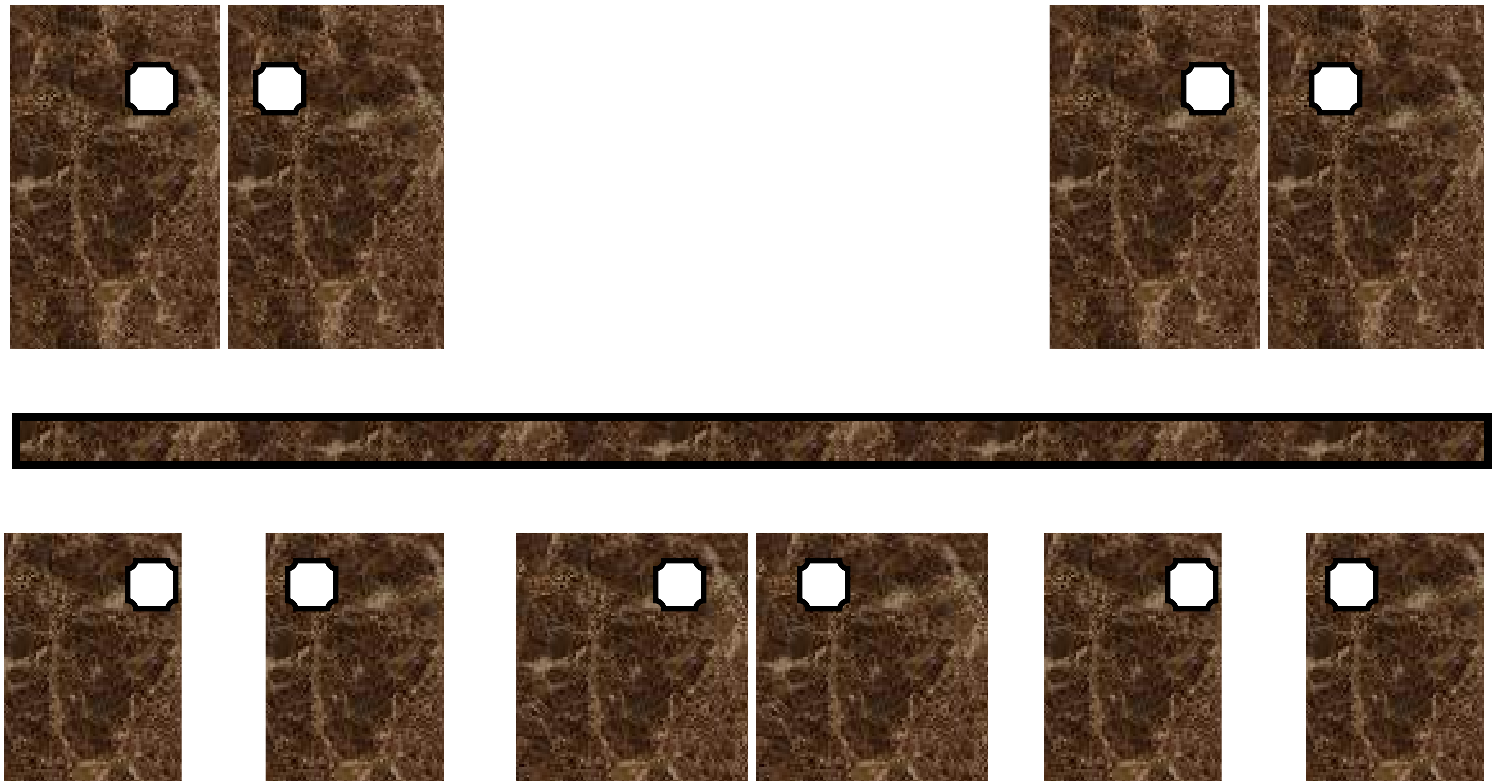
# *KitchenViewer* Example



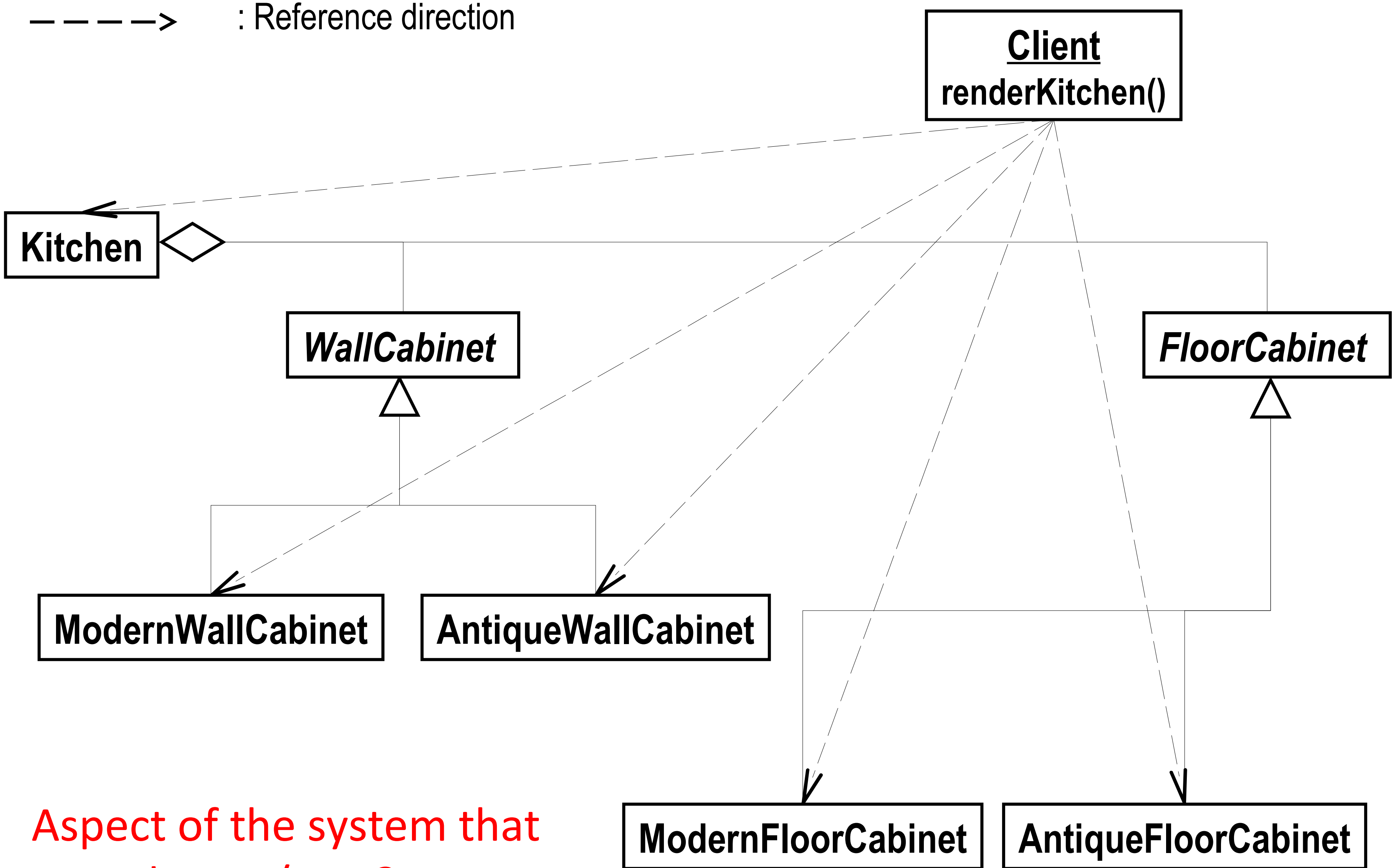

Modern | Classic | Antique | Arts & Crafts

# Selecting *Antique* Style



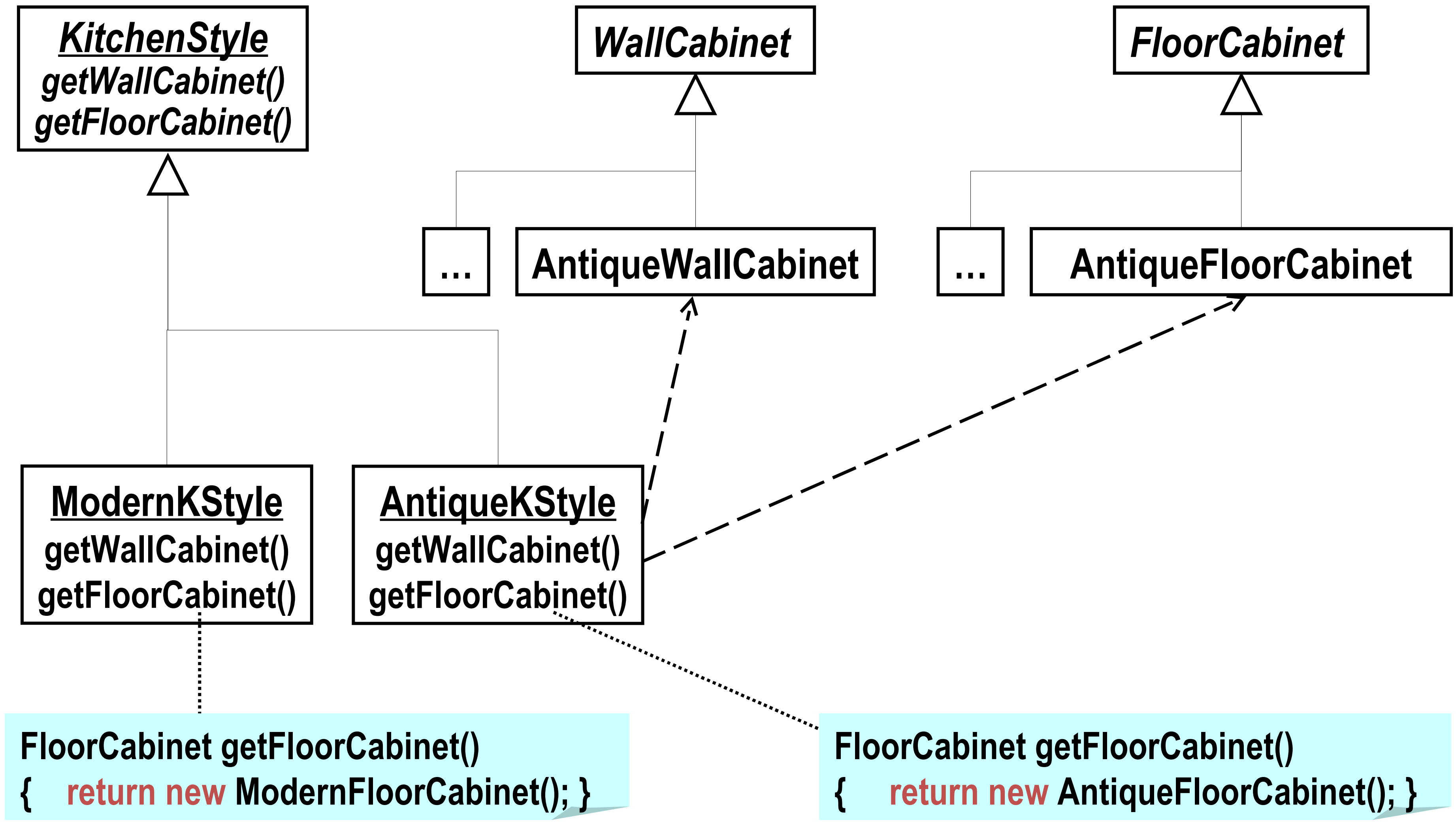
Modern | Classic | Antique | Arts & Crafts

# *KitchenViewer* Using Standard Inheritance

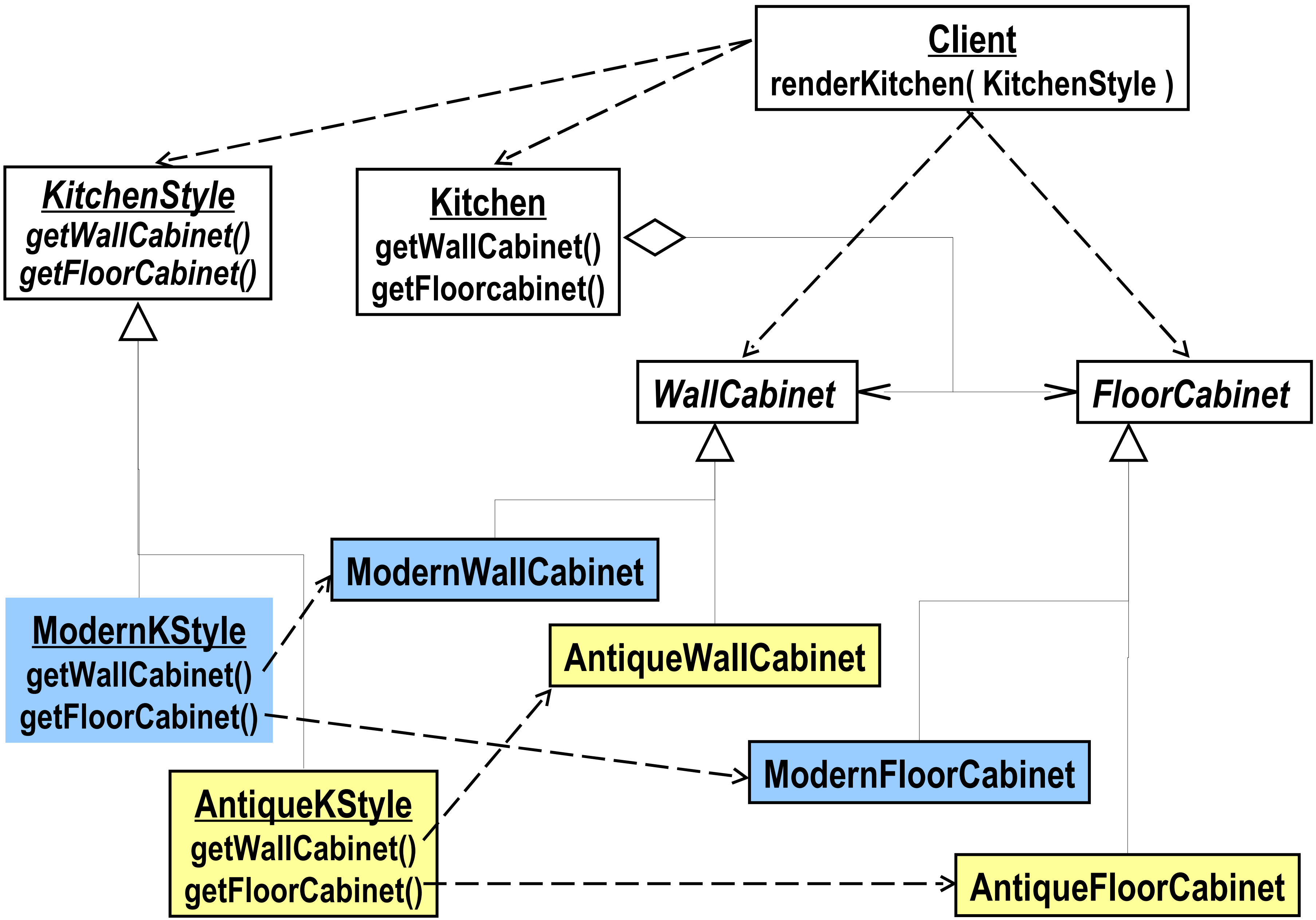



Aspect of the system that may change/vary?

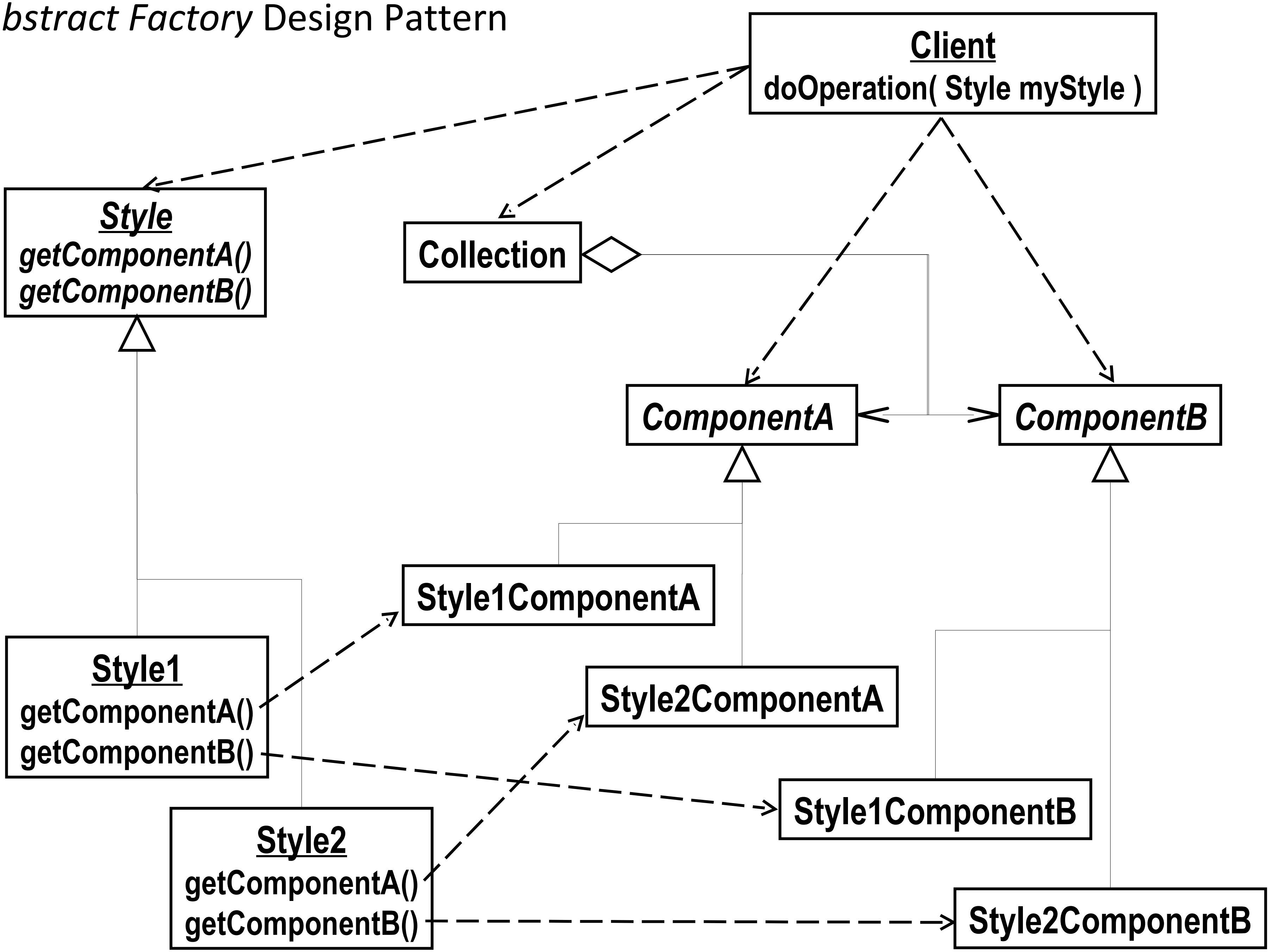
# *The Abstract Factory* Idea



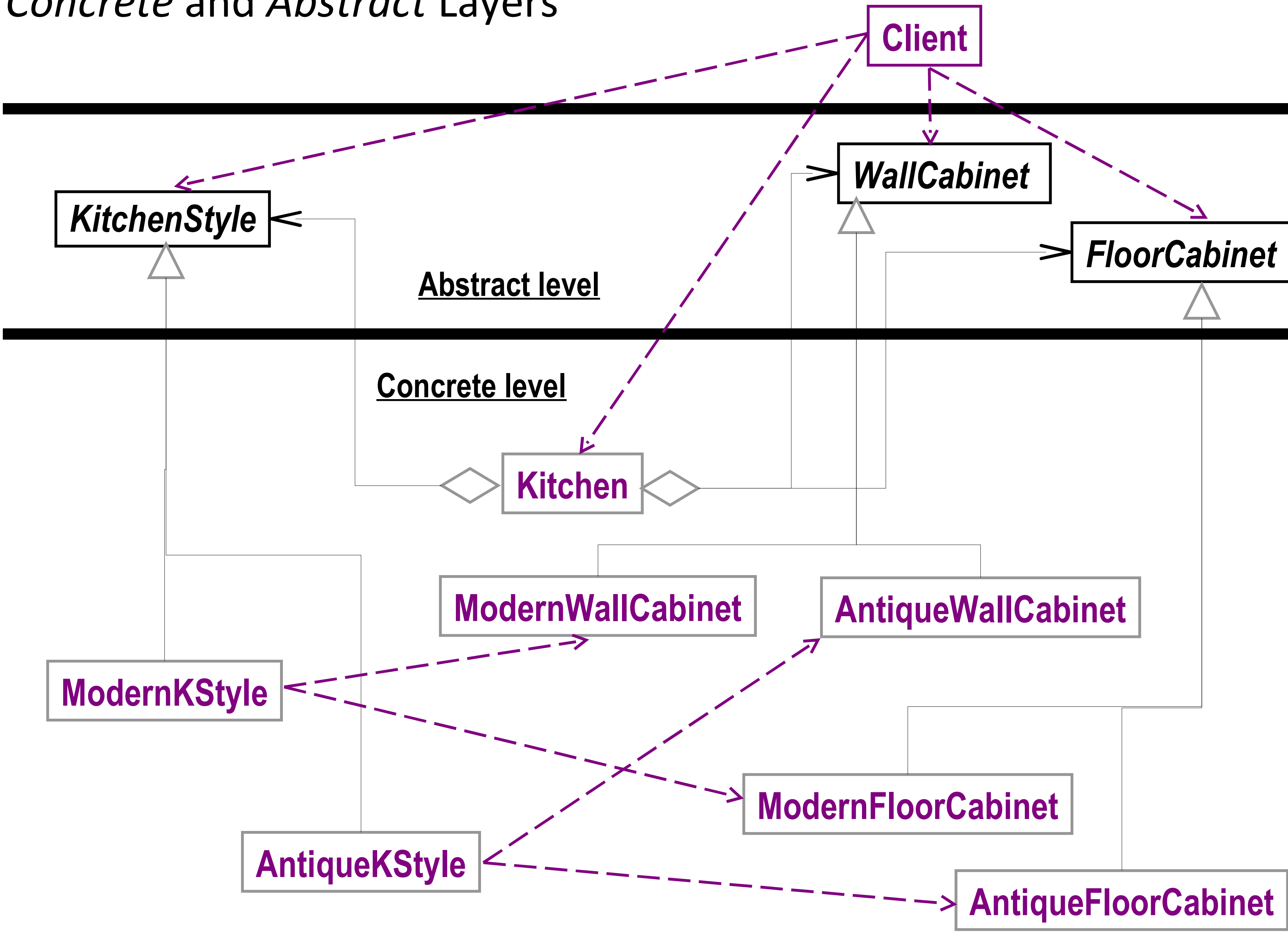
# *Abstract Factory* Design Pattern Applied to *KitchenViewer*



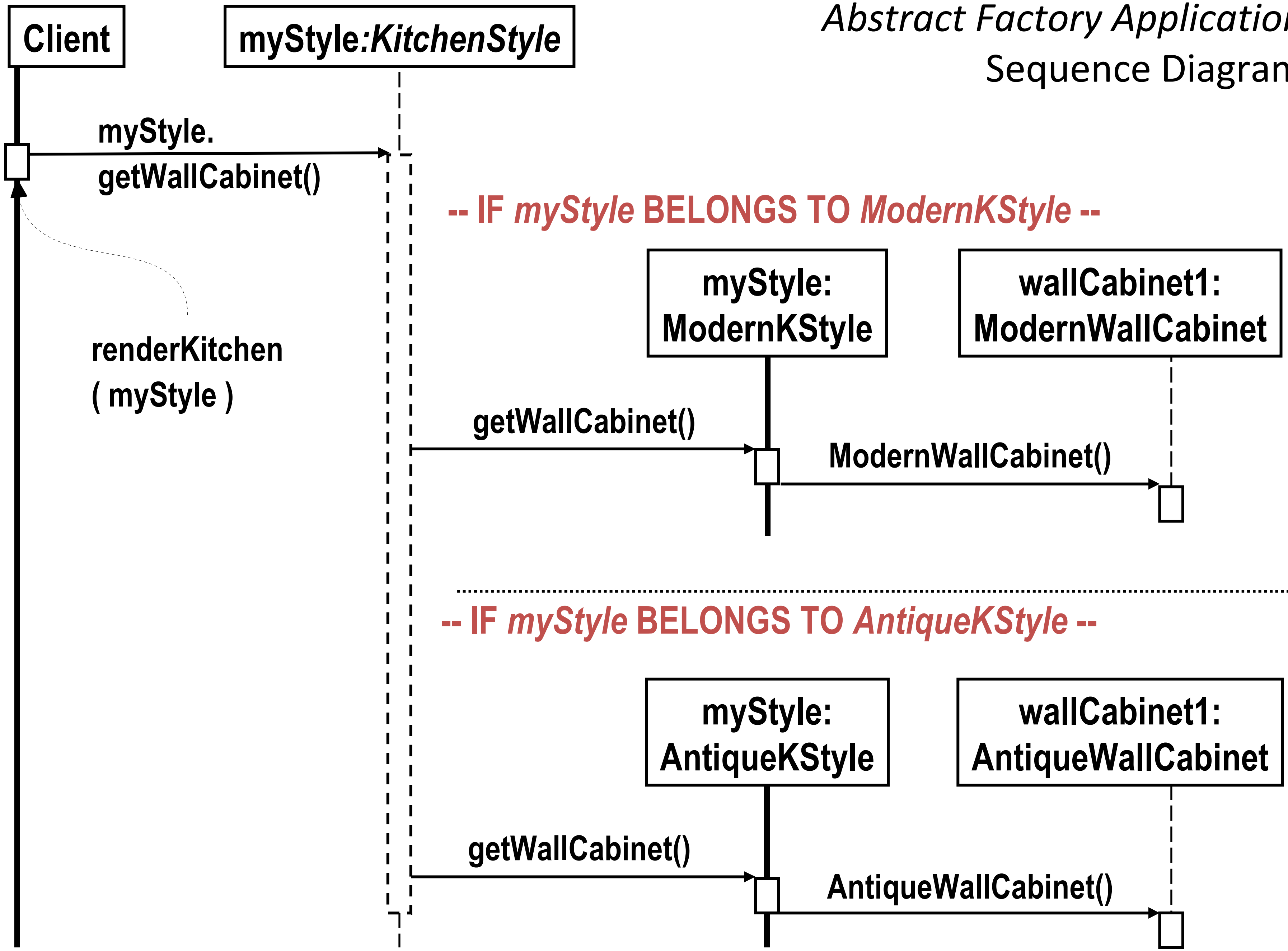
# *Abstract Factory* Design Pattern



# *Concrete* and *Abstract* Layers



# *Abstract Factory Application*
Sequence Diagram



*Potential use of this* Design Pattern?