CS 130 SOFTWARE ENGINEERING

# DESIGN PATTERNS

## INTRODUCTION, STRATEGY, OBSERVER MEDIATOR

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# AGENDA

- Strategy Pattern (Chapter 1 in Head First)
- Observer Pattern (Chapter 2 in Head First)
- Mediator Pattern
- Index Cards

# DESIGN PATTERN, DEFINED

- "A solution to a problem in a context."
- "A language for communication solutions with others."

- Pattern languages exist for many problems, but we focus on design
- Best known: "Gang of Four" (Gamma, Helm, Johnson, Vlissides)
  - *Design Patterns: Elements of Reusable Object-Oriented Software*

# CAVEATS

- Design patterns are not a substitute for thought
- Class names and directory structures do not equal good design
- Design patterns have tradeoffs
  - We'll talk about the *mediator* pattern. It does not remove complexity in interactions but just provides a structure for centralizing it.
- Design patterns depend on the programming language
  - Certain language restrictions may necessitate certain patterns (e.g., patterns related to object creation and destruction)

# MOTIVATION FOR DESIGN PATTERNS

- They provide an abstraction of the design experience
  - Can often serve as a reusable base of experience
- They provide a common vocabulary for discussing complete system designs
- They reduce system complexity by naming abstractions
  - Thereby increasing program comprehension and reducing learning time with a new piece of code
- They provide a target for the reorganization or refactoring of class hierarchies

# PIECES OF A DESIGN PATTERN

- Pattern name and classification
- Intent
- Also known as
- Justification
- Applicability
- Structure
- Participants
- Collaborations
- Consequences
- Implementation
- Sample code
- Known uses
- Related patterns

# RATIONALE FOR DESIGN PATTERNS

- Shared pattern vocabularies are powerful
- Patterns allow you to say more with less
- Reusing tried and tested methods
- Focus is on developing flexible, maintainable programs

# STRATEGY

# SIMUDUCK

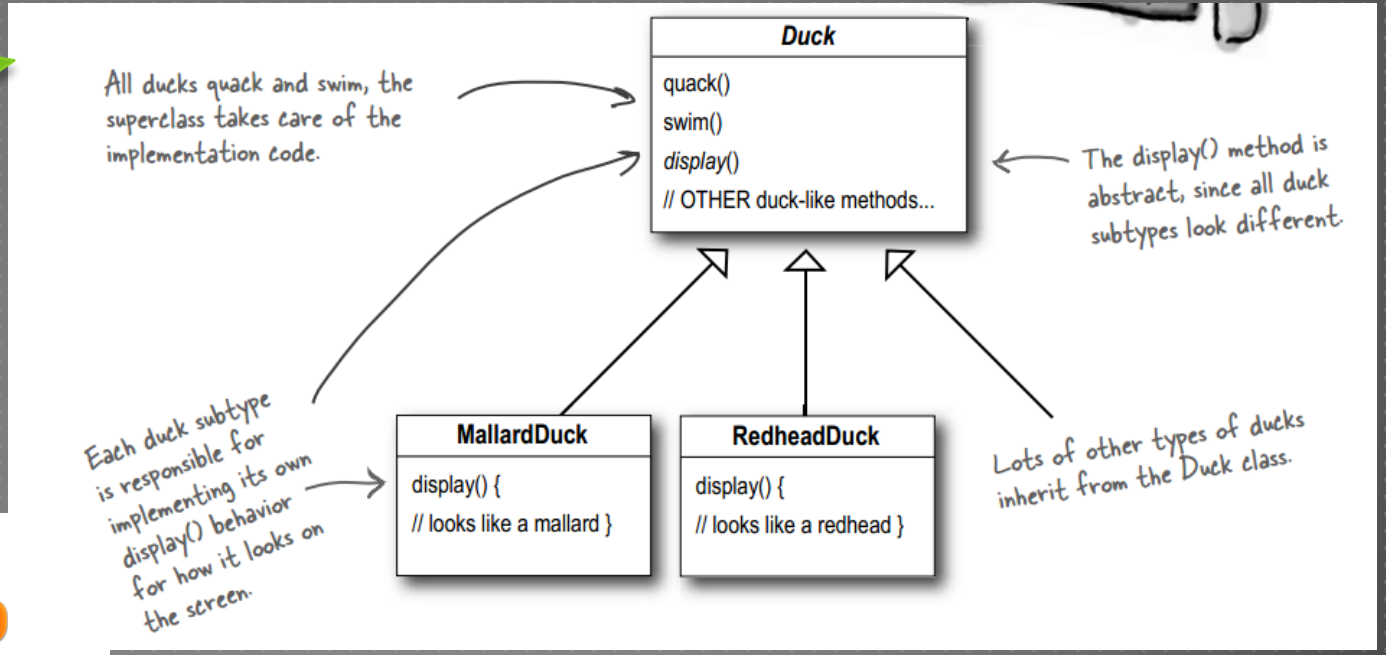
The ducks should be able to swim!

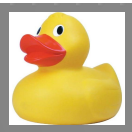
We should have Mallard ducks!

The ducks should quack!

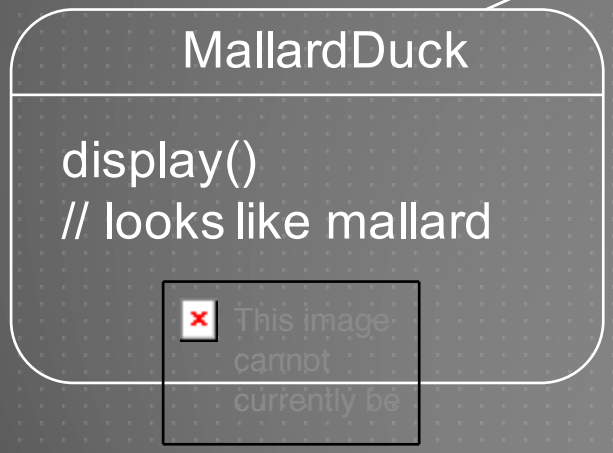
What about a redheaded duck?

Don't ducks fly, too?



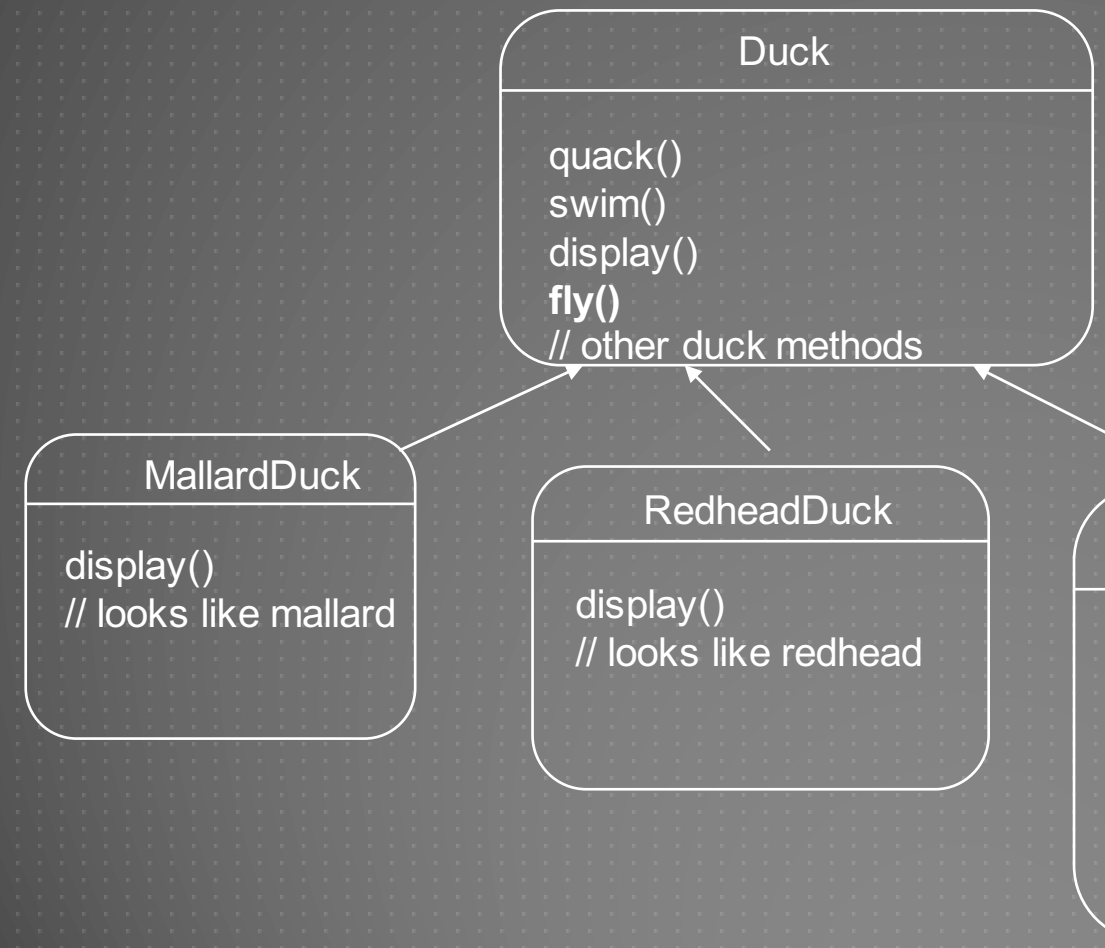
# SIMPLE SIMULATION OF DUCK BEHAVIOR



Other duck types

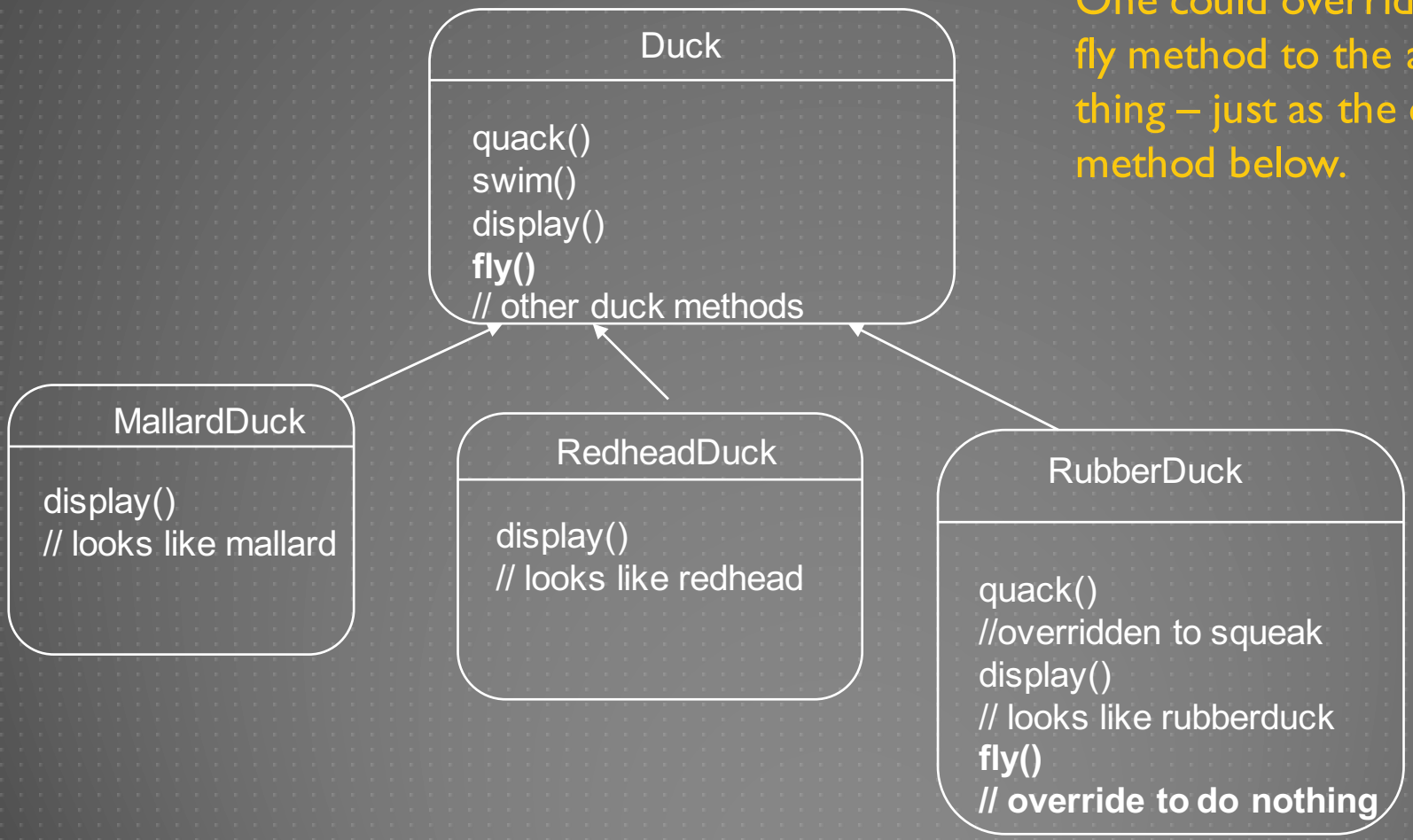
# THINK-PAIR-SHARE




**(A) If we add a "fly" method to the duck, what will we do for the kinds of ducks that do not fly?**

**(B) How would you change the program so that "fly" behavior can be added optionally to certain ducks only?**

# TRADEOFFS IN USE OF INHERITANCE AND MAINTENANCE




One could override the fly method to the appropriate thing – just as the quack method below.

# EXAMPLE COMPLICATED: ADD A WOODEN DECOY DUCKS TO THE MIX

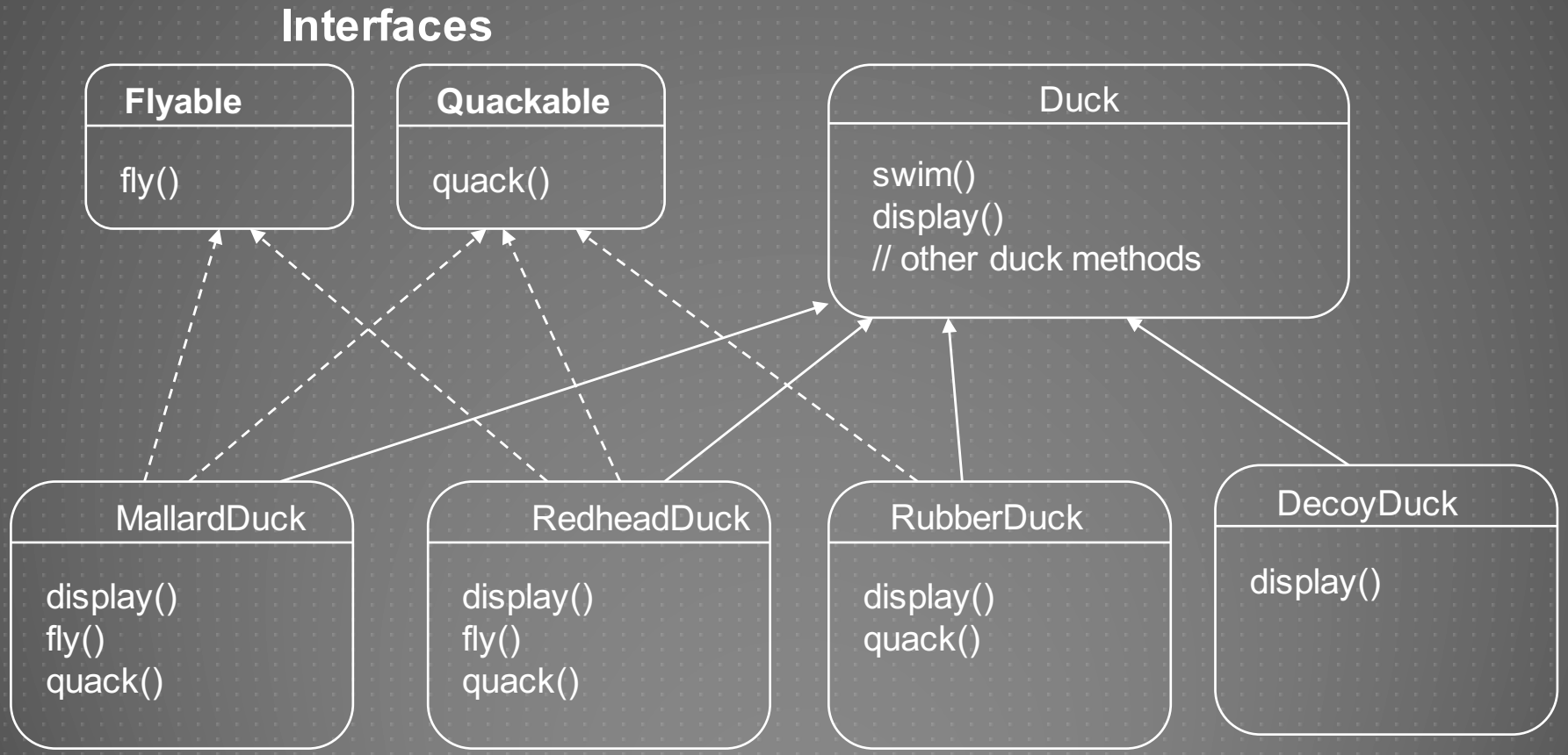
DecoyDuck

```
quack(){
// override to do nothing
}
display()
// display decoy duck
fly (){
//override to do nothing
}
```

Inheritance is not always the right answer. Every new class that inherits unwanted behavior needs to be overridden.

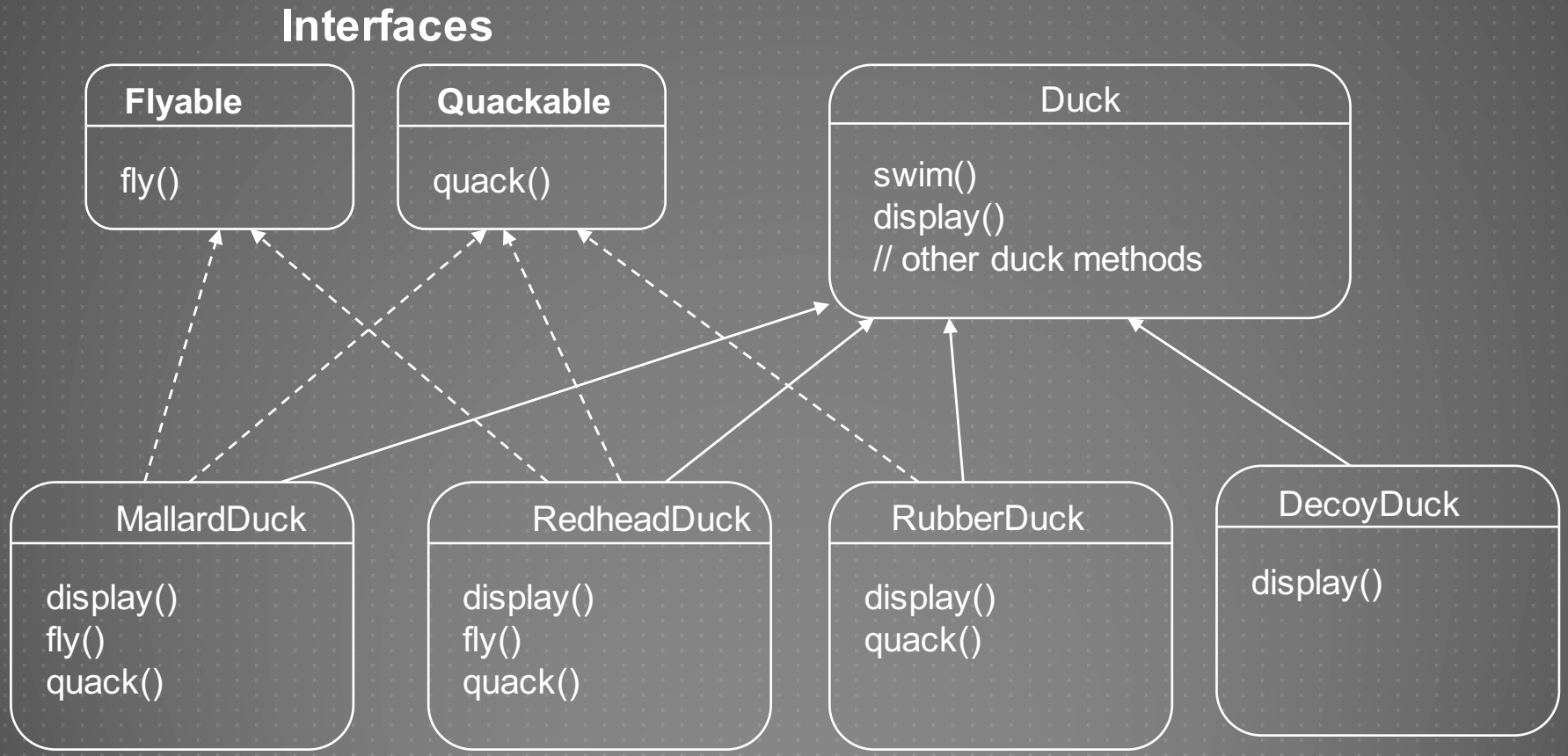
**How about using interfaces instead?**

# DUCK SIMULATION RECAST USING INTERFACES.



# THINK-PAIR-SHARE

## *WHAT ARE PROS AND CONS OF THIS DESIGN?*

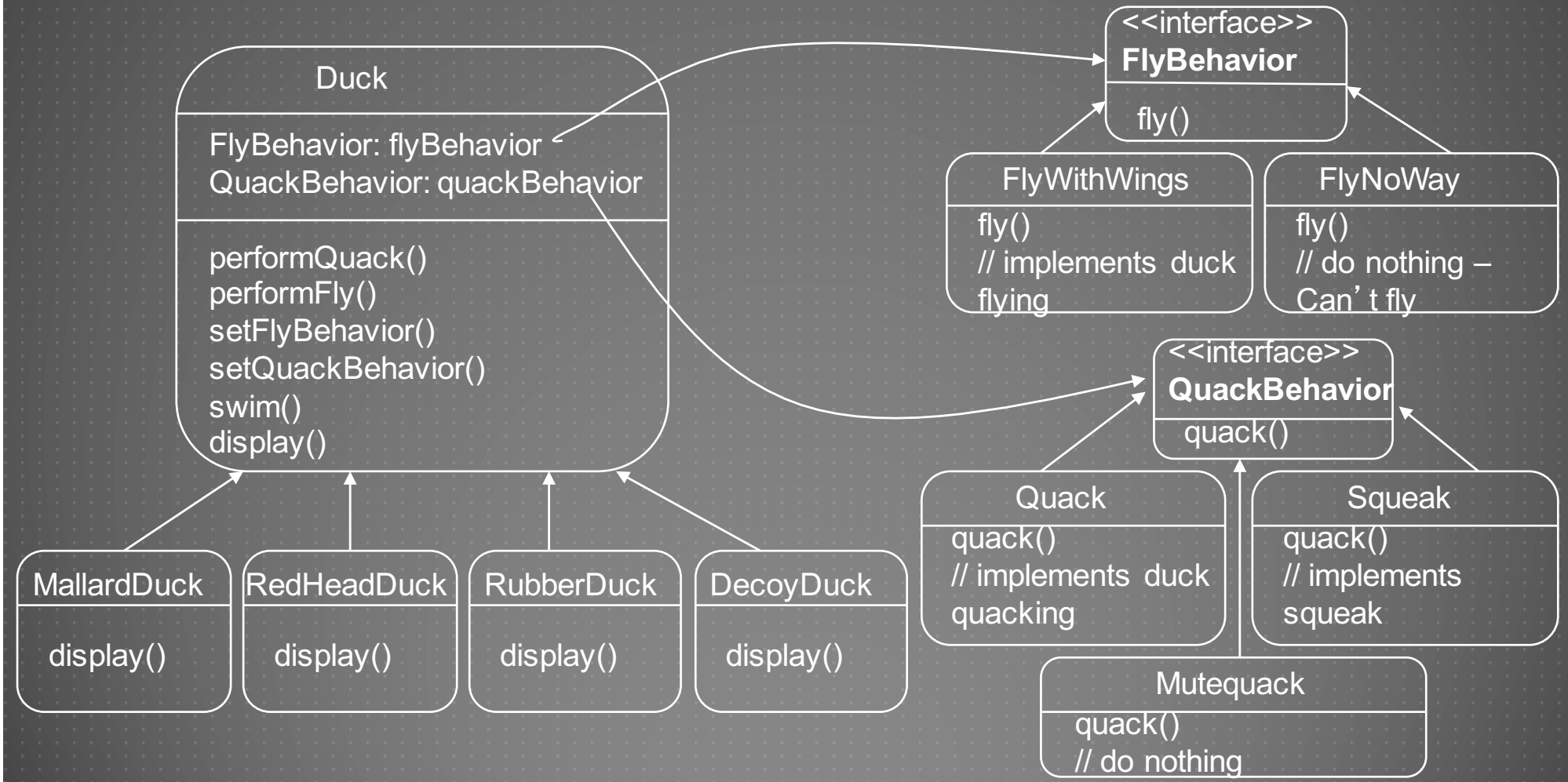


# PROS AND CONS

- Not all inherited methods make sense for all subclasses – hence inheritance is not the right answer
- But by defining interfaces, every class that needs to support that interface needs to implement that functionality… destroys code reuse!
- So if you want to change the behavior defined by interfaces, every class that implements that behavior may potentially be impacted

**And….**

# ALTERNATIVE DESIGN: STRATEGY



```
public abstract class Duck {
        FlyBehavior flyBehavior;
        QuackBehavior quackBehavior;

        public Duck() {       }
        public void setFlyBehavior (FlyBehavior fb) {
                flyBehavior = fb;
        }
        public void setQuackBehavior(QuackBehavior qb) {
                quackBehavior = qb;
        }
        abstract void display();

        public void performFly() {
                flyBehavior.fly();
        }
        public void performQuack() {
                quackBehavior.quack();
        }
        public void swim() {
                System.out.println("All ducks float, even decoys!");
        }
}
```

```
package headfirst.strategy;

public class ModelDuck extends Duck {
        public ModelDuck() {
                flyBehavior = new
FlyNoWay();
                quackBehavior = new
Quack();
        }

        public void display() {
                System.out.println("I'm a
model duck");
        }
}
```

```
package headfirst.strategy;

public class FlyRocketPowered implements
FlyBehavior {
        public void fly() {
                System.out.println("I'm
flying with a rocket");
        }
}
```

```
package headfirst.strategy;

public class MiniDuckSimulator {

        public static void main(String[] args) {

                MallardDuck     mallard = new MallardDuck();
                RubberDuck      rubberDuckie = new RubberDuck();
                DecoyDuck       decoy = new DecoyDuck();

                ModelDuck       model = new ModelDuck();

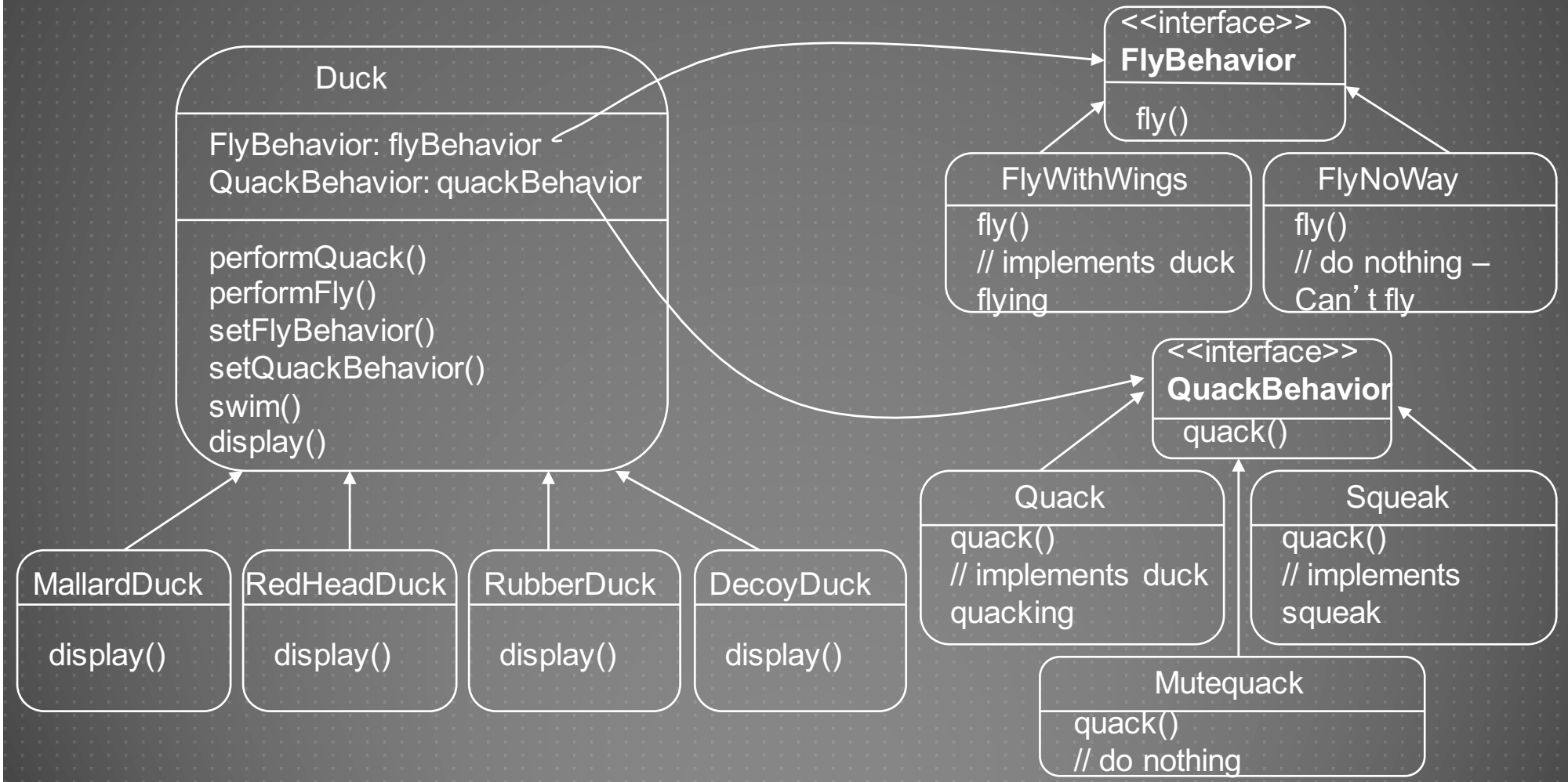
                mallard.performQuack();
                rubberDuckie.performQuack();
                decoy.performQuack();

                model.performFly();
                model.setFlyBehavior(new FlyRocketPowered());
                model.performFly();
        }
}
```

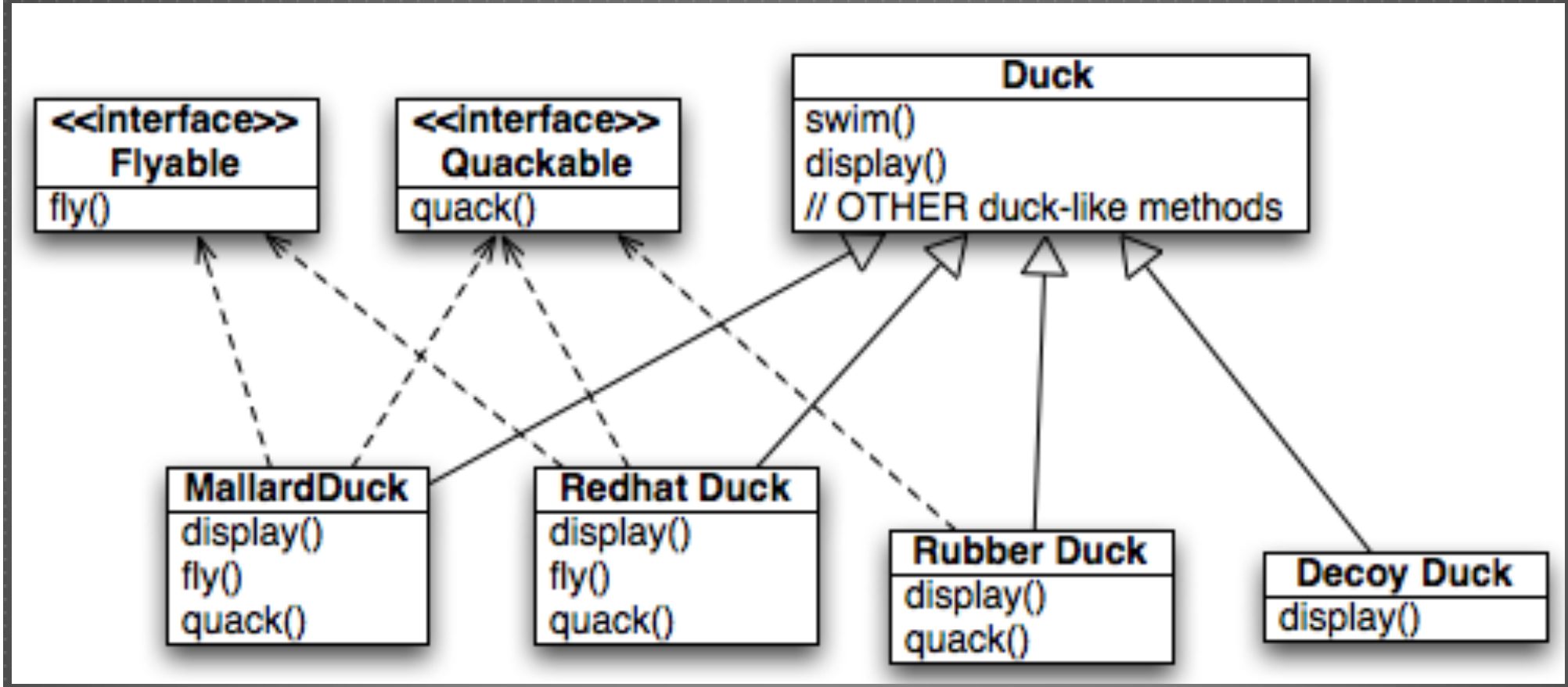
# THE STRATEGY PATTERN

The Strategy Pattern defines a family of algorithms, Encapsulates each one, and makes them interchangeable. Strategy lets the algorithm vary independently from clients that use it.

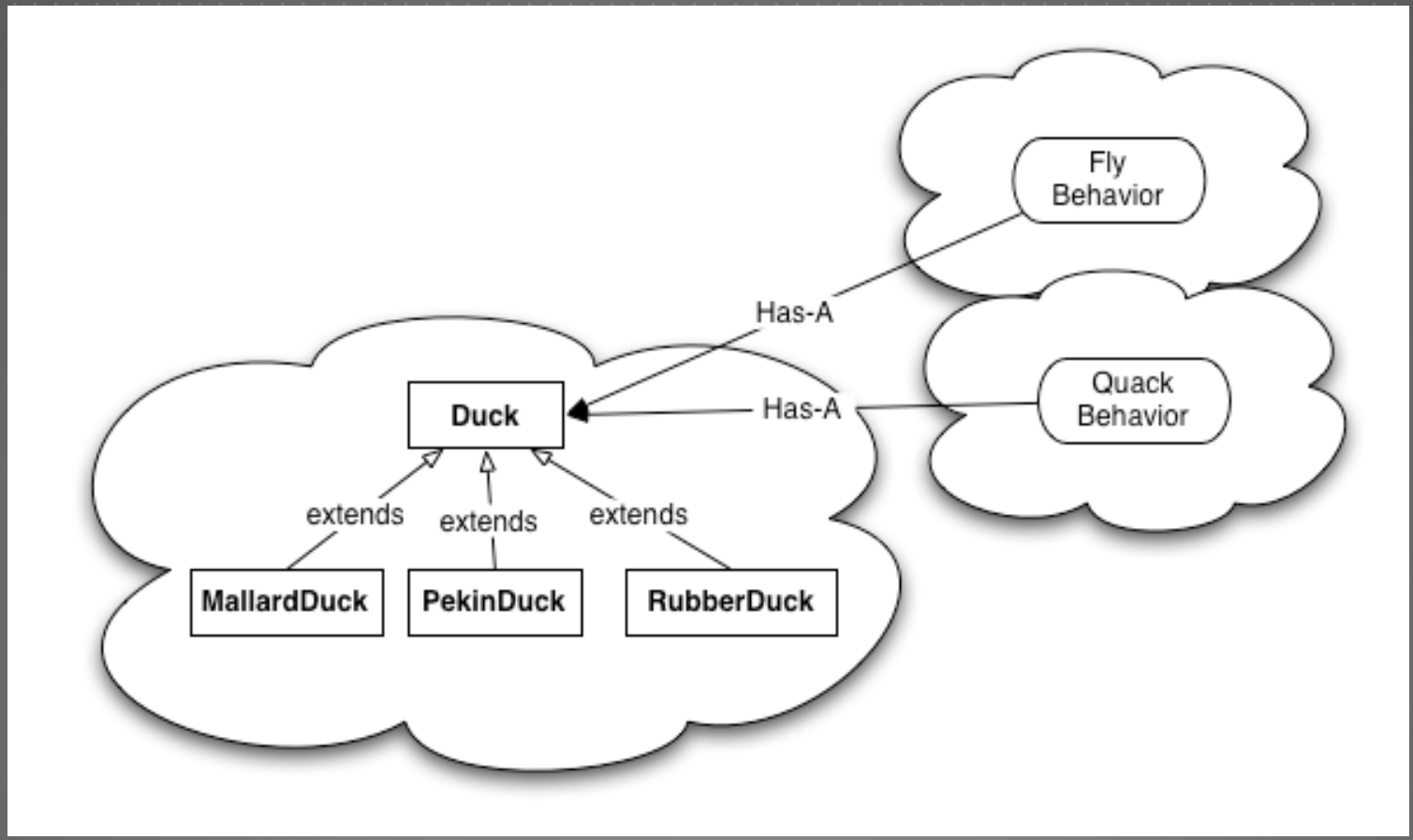
# RECAP QUESTION 1: WHAT IS THE STRATEGY AND CONCRETE STRATEGY CLASSES RESPECTIVELY?



# RECAP QUESTION 2: WHAT ARE THE DISADVANTAGE OF THIS DESIGN?

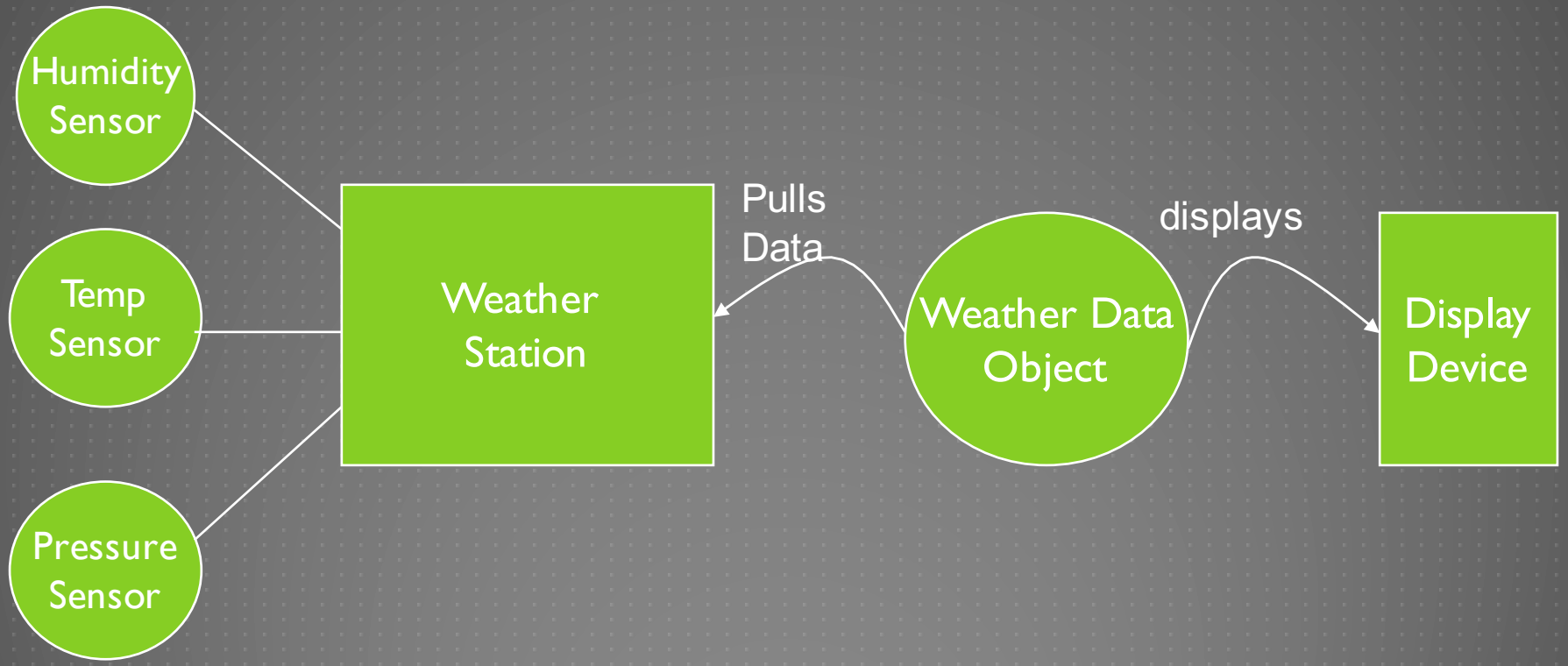


# RECAP QUESTION 3: WHICH DECISIONS ARE LIKELY TO VARY ACCORDING TO THIS DESIGN?

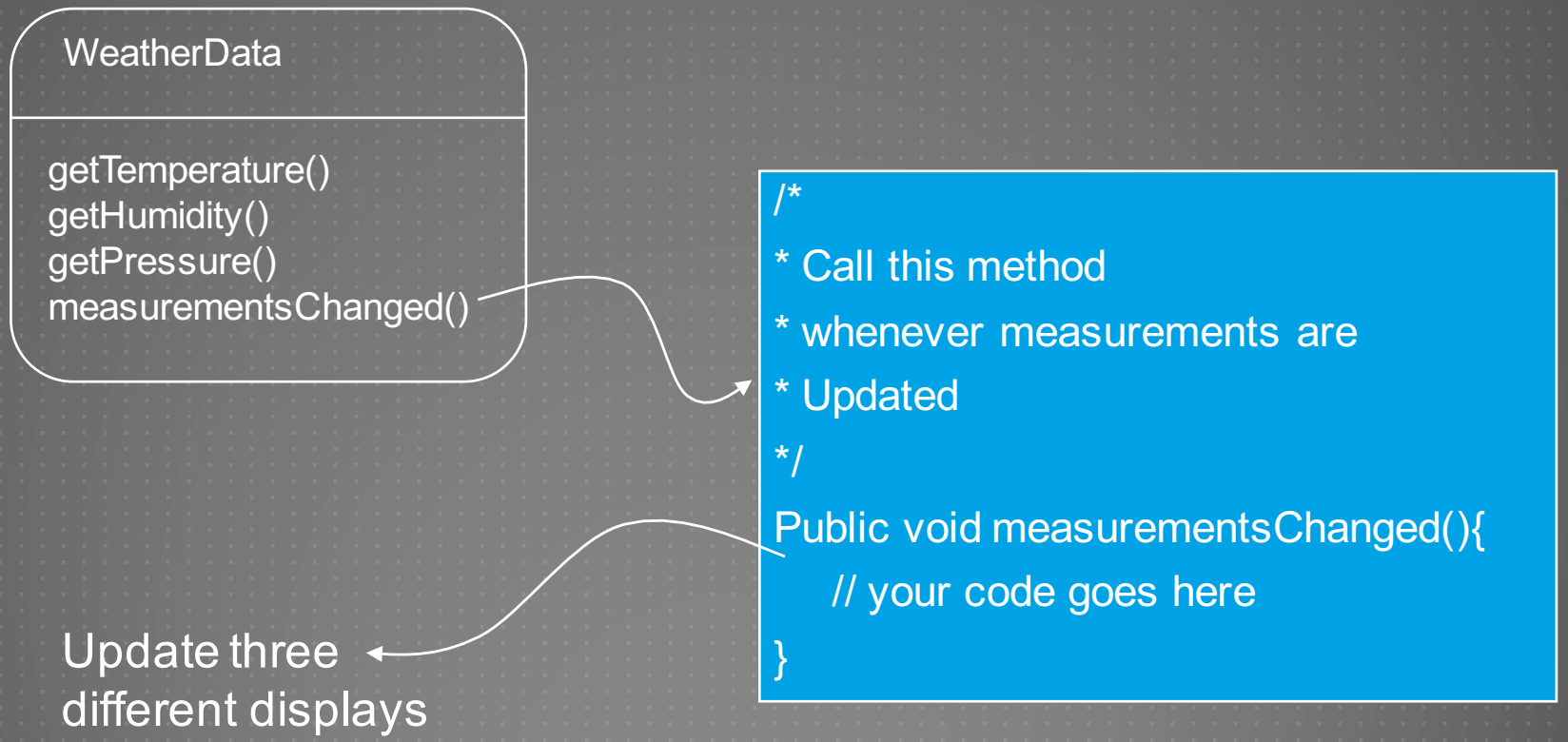


# THE OBSERVER PATTERN

# WEATHER MONITORING APPLICATION



# WHAT NEEDS TO BE DONE?



# PROBLEM SPECIFICATION

- weatherData class has three getter methods
- measurementsChanged() method called whenever there is a change
- Three display methods needs to be supported: current conditions, weather statistics and simple forecast
- System should be expandable

# FIRST CUT AT IMPLEMENTATION

```
public class WeatherData {

    public void measurementsChanged(){
            float temp = getTemperature();
            float humidity = getHumidity();
            float pressure = getPressure();

            currentConditionsDisplay.update (temp, humidity, pressure);
            statisticsDisplay.update (temp, humidity, pressure);
            forecastDisplay.update (temp, humidity, pressure);
    }
    // other methods
}
```

# THINK-PAIR-SHARE

- How should the code be updated if we want to support another type of displays beyond the three?

```
public class WeatherData {

    public void measurementsChanged(){
            float temp = getTemperature();
            float humidity = getHumidity();
            float pressure = getPressure();

            currentConditionsDisplay.update (temp, humidity, pressure);
            statisticsDisplay.update (temp, humidity, pressure);
            forecastDisplay.update (temp, humidity, pressure);
    }
    // other methods
}
```

# FIRST CUT AT IMPLEMENTATION

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        forecastDisplay.update (temp, humidity, pressure);
    }
    // other methods
}
```

Area of change which can be Managed better by encapsulation

By coding to concrete implementations there is no way to add additional display elements without making code change

# OBSERVER PATTERN

**The Observer Pattern** defines a one-to-many dependency between objects so that when one object changes state, all of its dependents are notified and updated automatically.

# BASIS FOR OBSERVER PATTERN

- Fashioned after the publish/subscribe model
- Works off similar to any subscription model
  - Buying newspaper
  - Magazines
  - List servers

# WEATHER DATA INTERFACES

```
public interface Subject {
    public void registerObserver(Observer o);
    public void removeObserver(Observer o);
    public void notifyObservers();
}
public interface Observer {
    public void update(float temp, float humidity, float pressure);
}
public interface DisplayElement {
    public void display();
}
```

# IMPLEMENTING SUBJECT INTERFACE

```
public class WeatherData implements Subject {
        private ArrayList observers;
        private float temperature;
        private float humidity;
        private float pressure;

        public WeatherData() {
                observers = new ArrayList();
        }
```

# REGISTER AND UNREGISTER

```
public void registerObserver(Observer o) {
        observers.add(o);
}

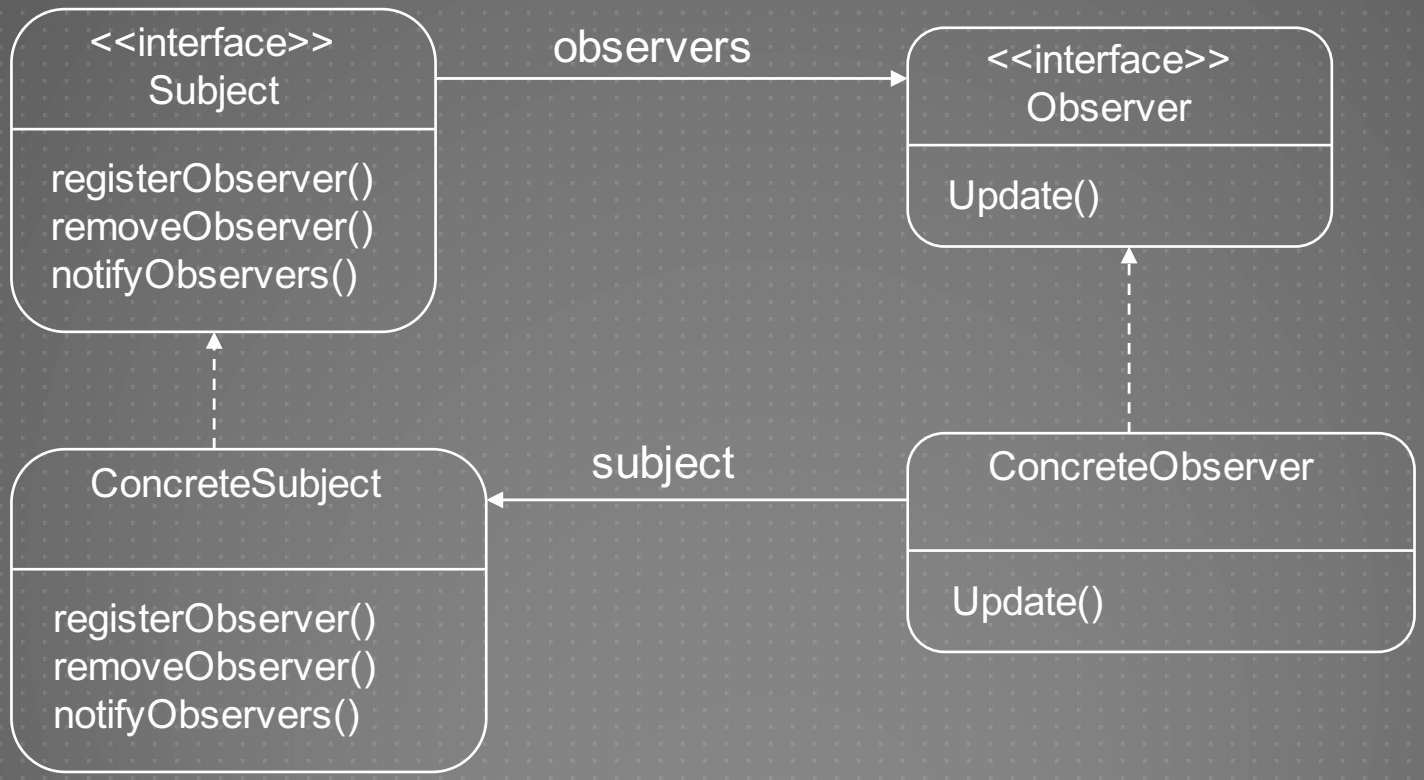
public void removeObserver(Observer o) {
        int i = observers.indexOf(o);
        if (i >= 0) {
                observers.remove(i);
        }
}
```

# NOTIFY METHODS

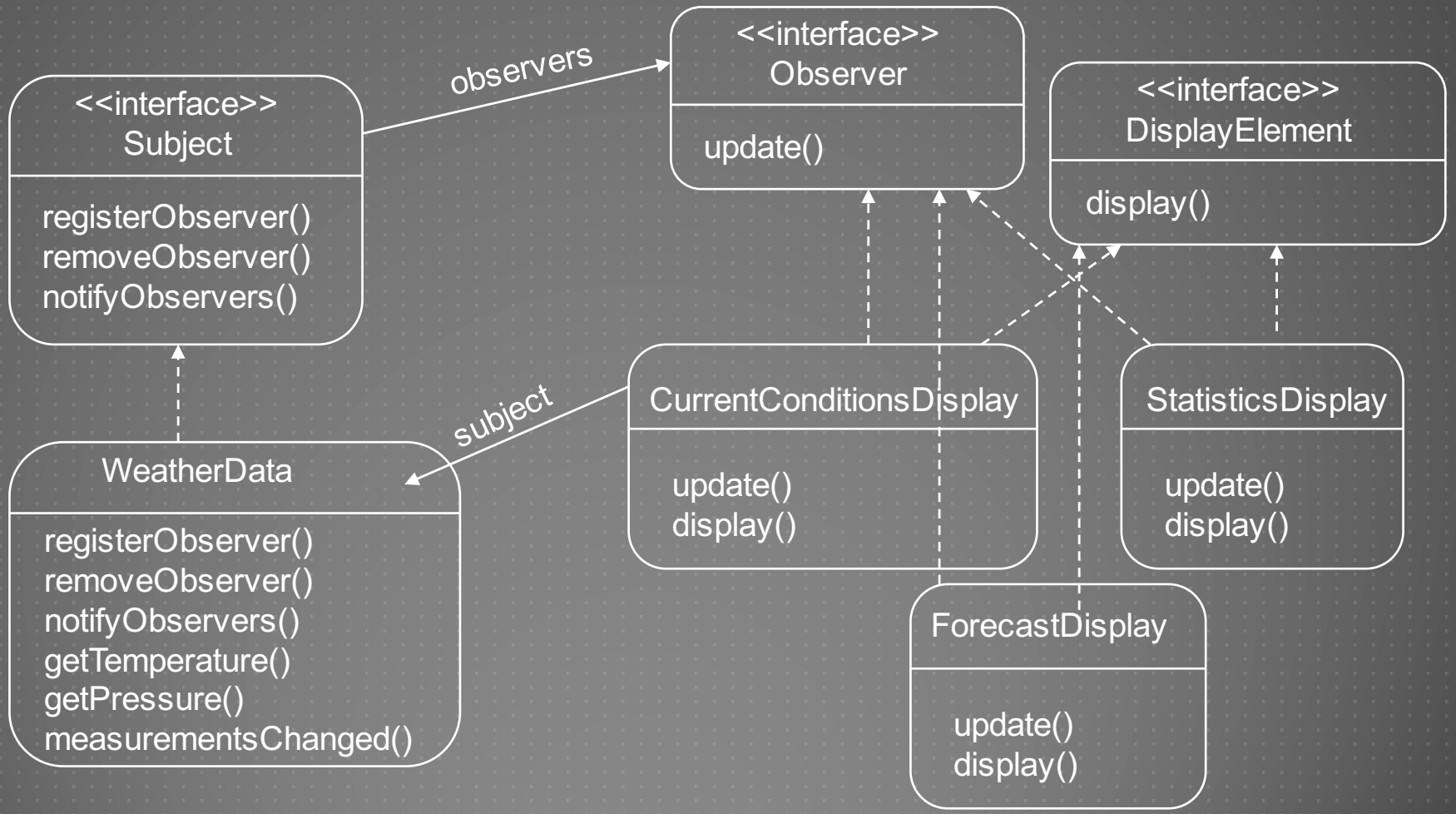
```
public void notifyObservers() {
        for (int i = 0; i < observers.size(); i++) {
                Observer observer = (Observer)observers.get(i);
                observer.update(temperature, humidity, pressure);
        }
}

public void measurementsChanged() {
        notifyObservers();
}
```

# OBSERVER PATTERN – CLASS DIAGRAM



# OBSERVER PATTERN – WEATHER DATA



# OBSERVER PATTERN – POWER OF LOOSE COUPLING

- The only thing that the subject knows about an observer is that it implements an interface
- Observers can be added at any time and subject need not be modified to add observers
- Subjects and observers can be reused or modified without impacting the other [as long as they honor the interface commitments]

# THINK-PAIR-SHARE

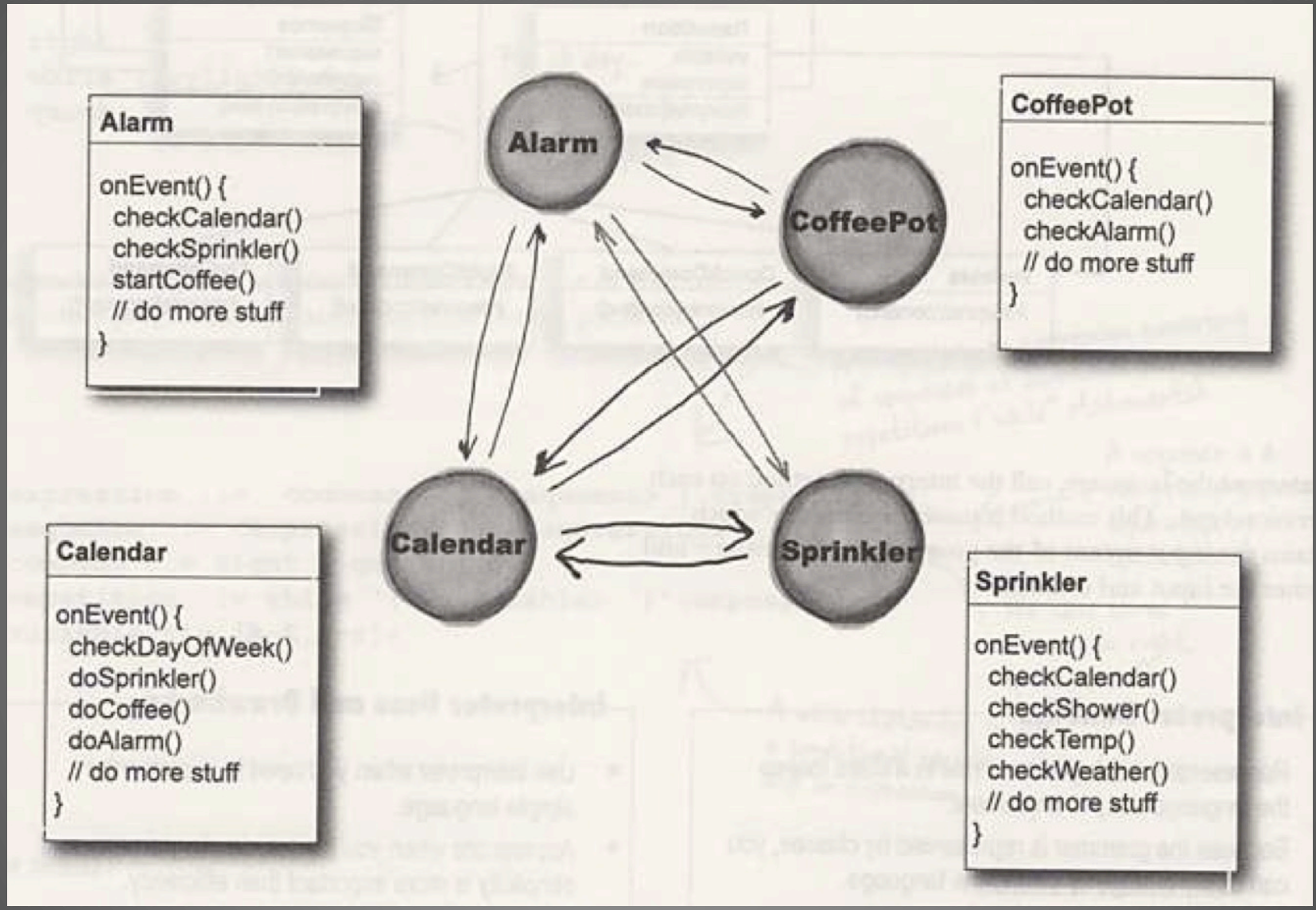
- In the observer pattern, which of the following types of changes are easily accommodated?
  - (A) adding a new type of observer
  - (B) adding a new type of subject
  - (C) selectively notifying different observers

# MEDIATOR

# MEDIATOR

- To centralize complex communications and control between related objects
- Scenario:
  - Bob had a Java enabled auto-house.
  - All of his appliances are designed to make his life easier
  - When Bob stops hitting the snooze button, his alarm clock tells the coffee maker to start brewing.
  - No coffee on the weekends
  - Turn off the sprinkler 15 minutes before a shower is scheduled.

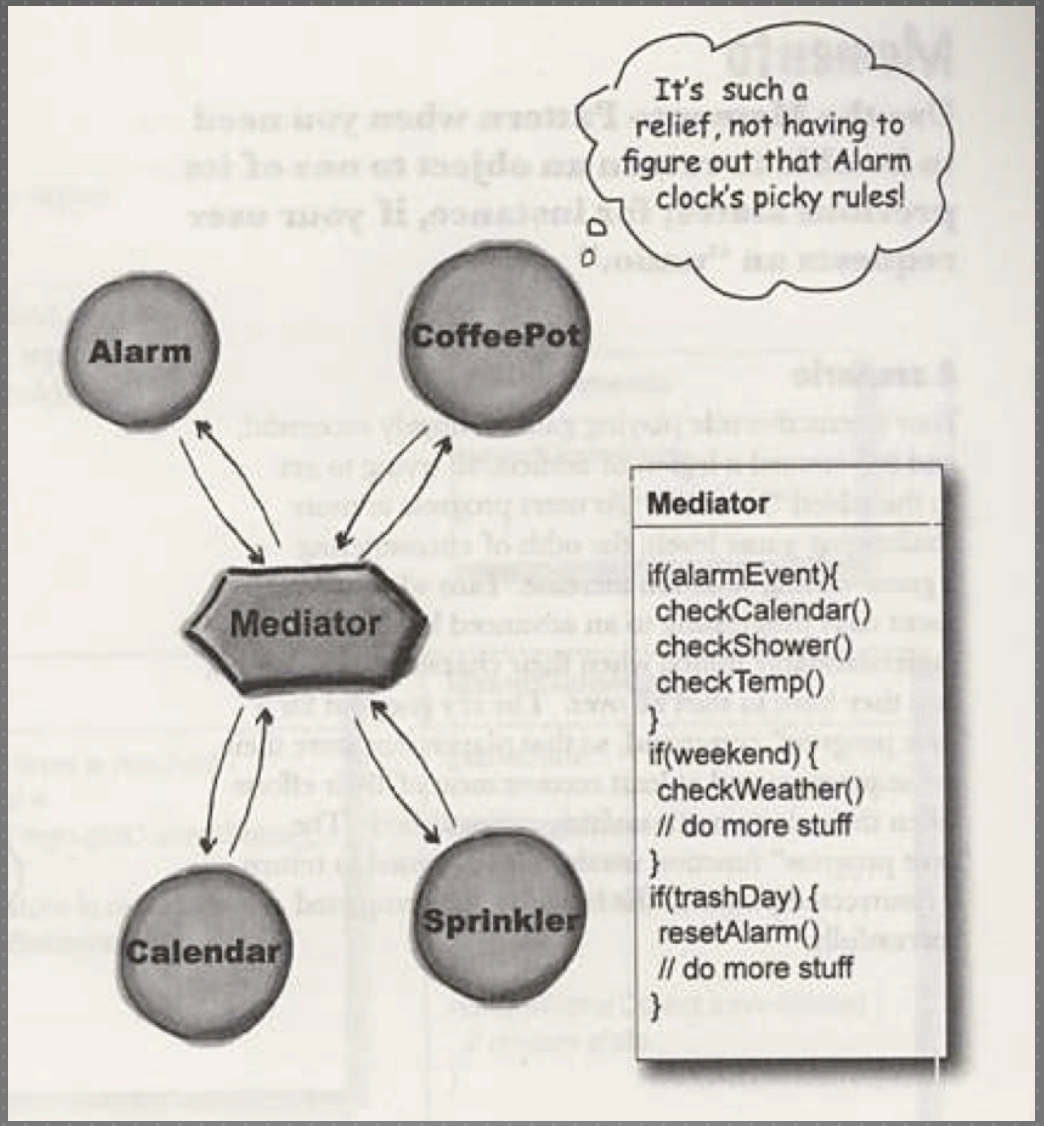
# COMPLEX INTER-COMMUNICATION



# MEDIATOR IN ACTION

- With a mediator added to the system all appliance objects can be greatly simplified
  - They tell the Mediator when their state changes
  - They respond to requests from the Mediator
- Before adding the mediators all objects need to know about each other

# MEDIATOR IN ACTION



# MEDIATOR IN ACTION

- With the mediator in place, all objects are all completely decoupled from each other.
- Mediator contains all control logic for the entire system.
- When an existing appliance needs a new rule or a new appliance is added to the system, you will know that all logic will be added to the mediator

# MEDIATOR BENEFITS

- Increase the reusability of the objects supported by the Mediator by decoupling them from the system
- Simplifies maintenance of the system by centralizing control logic
- Simplified and reduces the variety of messages sent between objects in the system

# MEDIATOR DRAWBACKS

- Without proper design, the mediator object itself can become overly complex.
- Mediator also exposes a single point of vulnerability and complexity.

# RECAP

- The Strategy Pattern defines a family of algorithms, and it lets the algorithm vary independently from clients that use it.
- The Observer Pattern defines a one-to-many dependency between objects so that when one object changes state, all of its dependents are notified and updated automatically.
- The Mediator Pattern encapsulates many to many dependencies between objects.

# QUESTIONS?