# Lecture 10

ECE 1145: Software Construction and Evolution

## Variability Management

## State Pattern

## (CH 11)

# Announcements

- Relevant Exercises: **11.4** 11.5
- **Code Review 1**
  - Groups on Canvas
  - Provide other team with your Iteration 3 (Release3) **by the start of class on Wednesday** (complete the Code Swap 1 assignment to confirm)
    - As a zip file or access to GitHub repo
  - Compete code review template and report
    - Time in class Wednesday
- **Midterm Oct. 18 (take-home) – 2 weeks from Today**
  - Midterm review on Wednesday Oct. 13
  - Access and submit via Canvas
  - ~24 hour window
  - Lectures 1 – 9, project iterations 1 – 3 and code review
- Iteration 4 (due Oct. 17) will be code quality improvements

# Questions for Today

How do we combine existing solutions without duplicating code?

# A New Customer!

We have been contacted by GammaTown! They want “almost the same” pay station, but with different rate structures during weekdays and weekends:

- Weekdays: linear rate (like AlphaTown)
- Weekends: progressive rate (like BetaTown)

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The two rate structures are already implemented, we just need a way to **select** based on the day.

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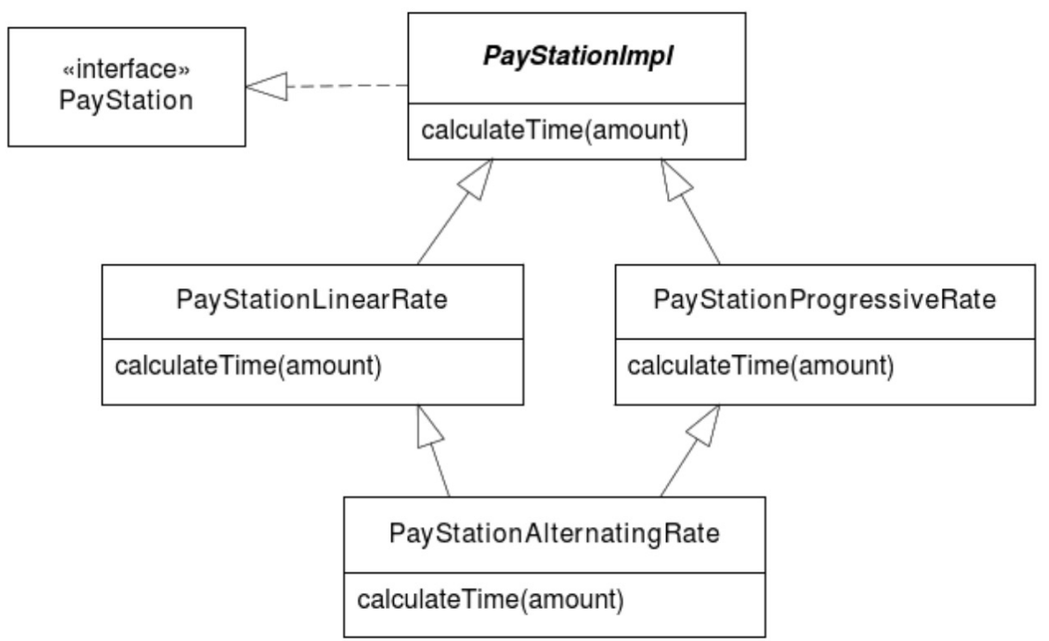


Figure 11.1: Multiple inheritance solution.

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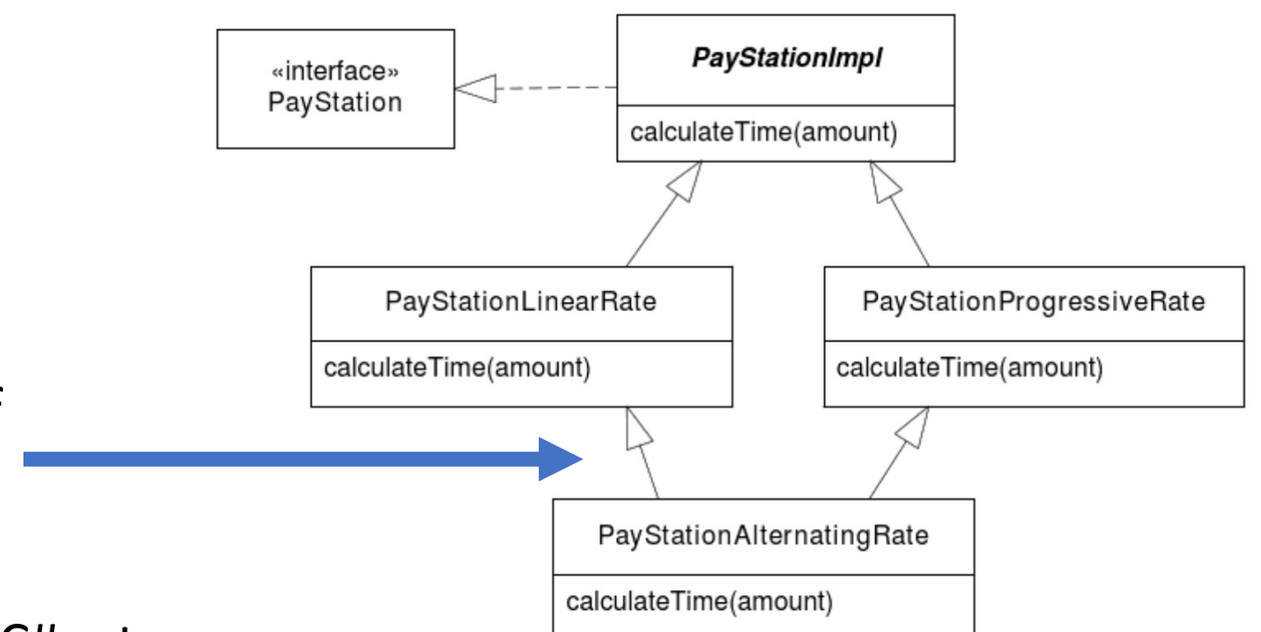



Figure 11.1: Multiple inheritance solution.

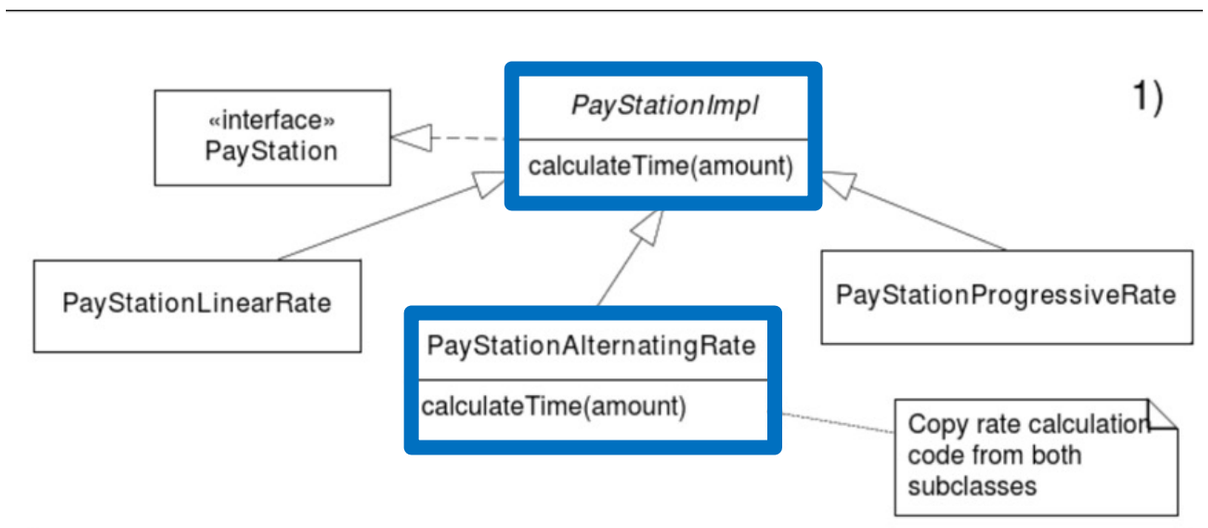
Multiple inheritance of implementation

- Supported in C++
- Not supported in Java, C#, etc.
- High risk of introducing defects!

# Polymorphic Solution Proposal

Other options:

1. Direct subclass of PayStationImpl



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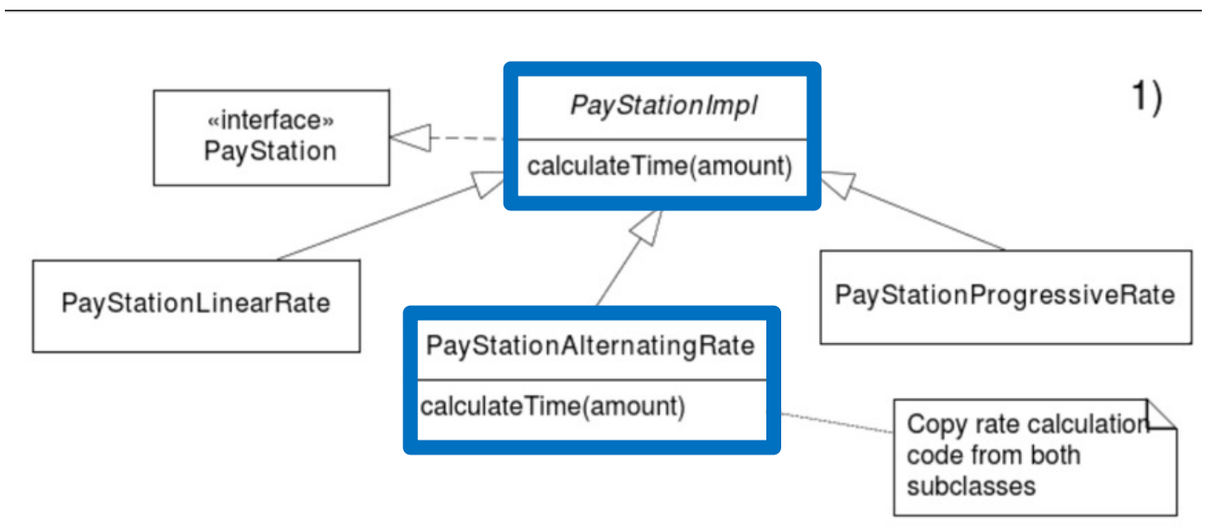

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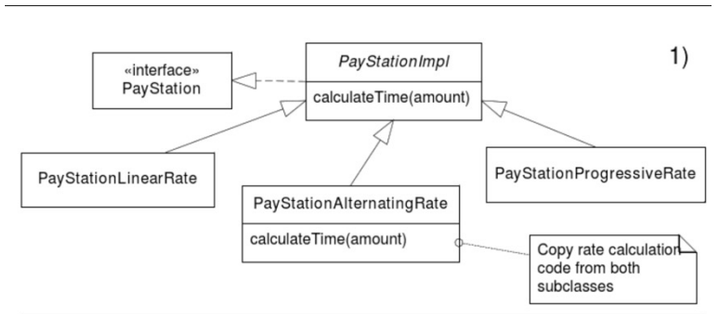


Other options:

1. Direct subclass of PayStationImpl
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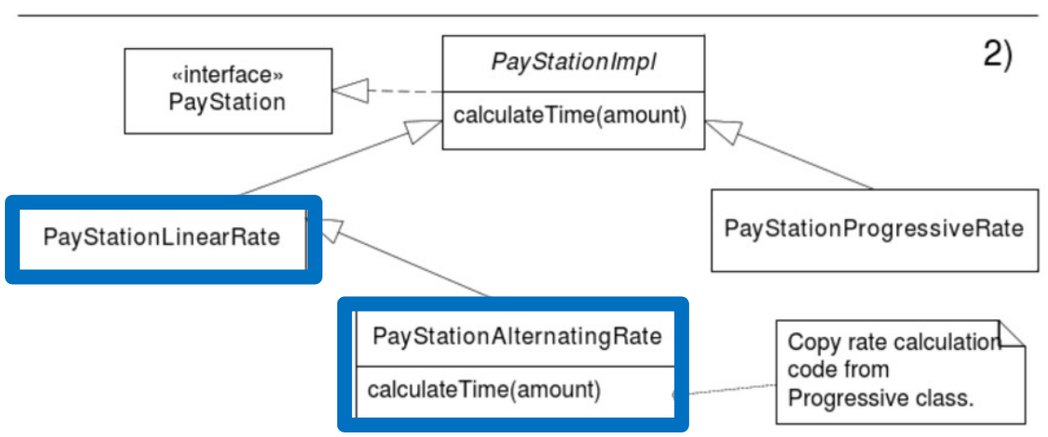
2. Sub-subclass of PayStationLinearRate



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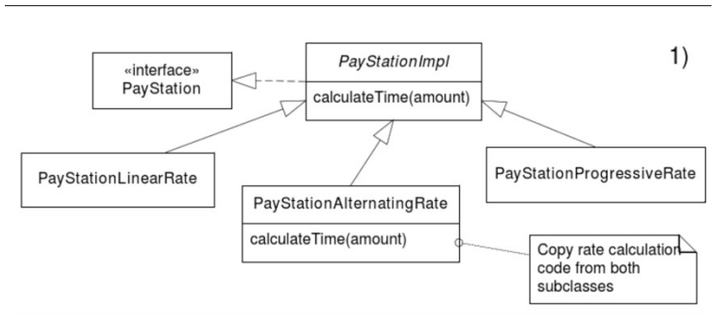


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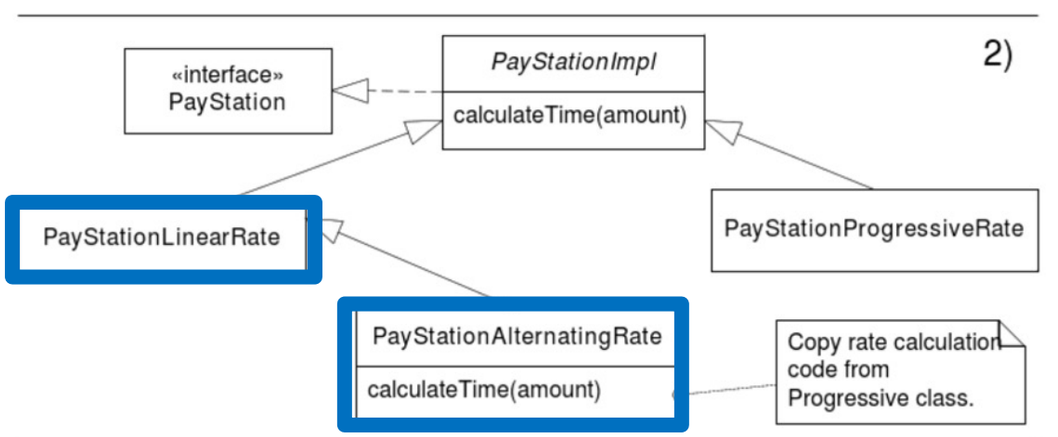
   - Avoids some duplication (but not all), and creates confusing asymmetry



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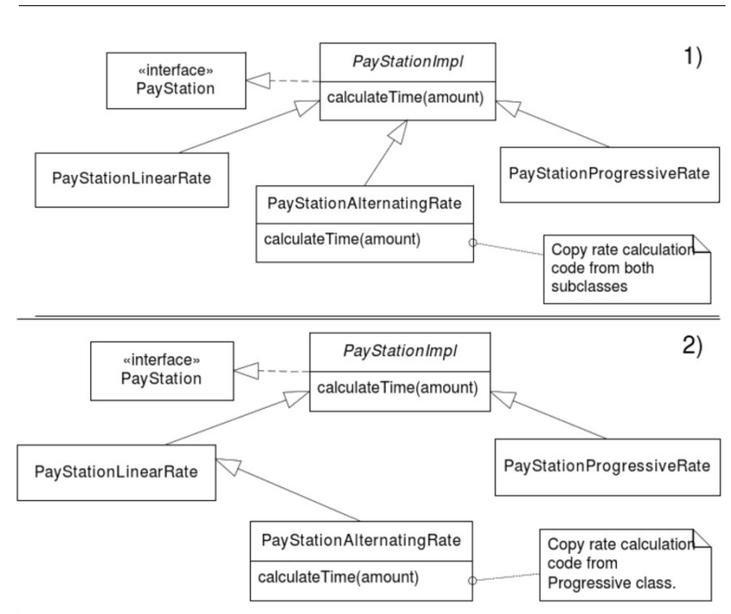


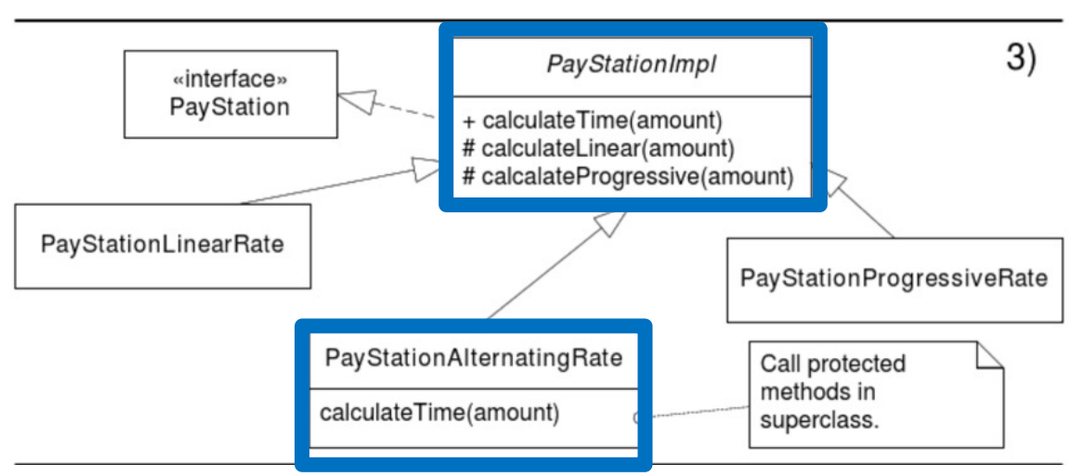

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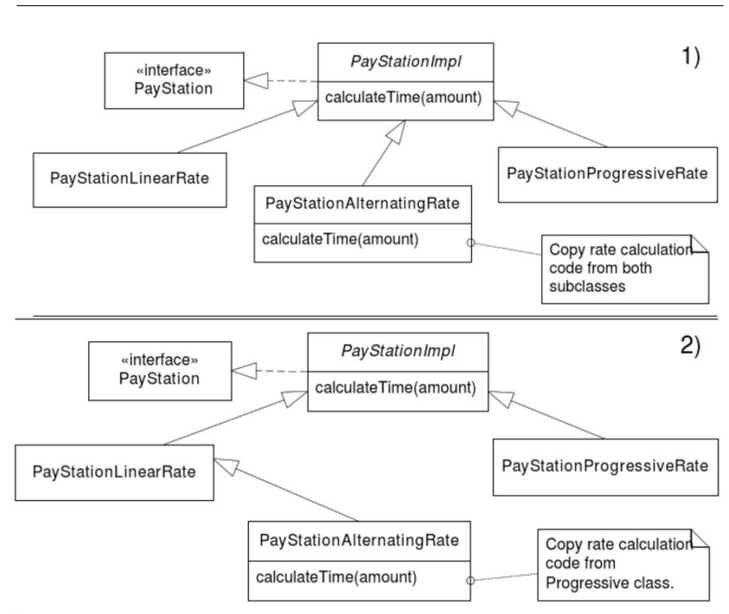


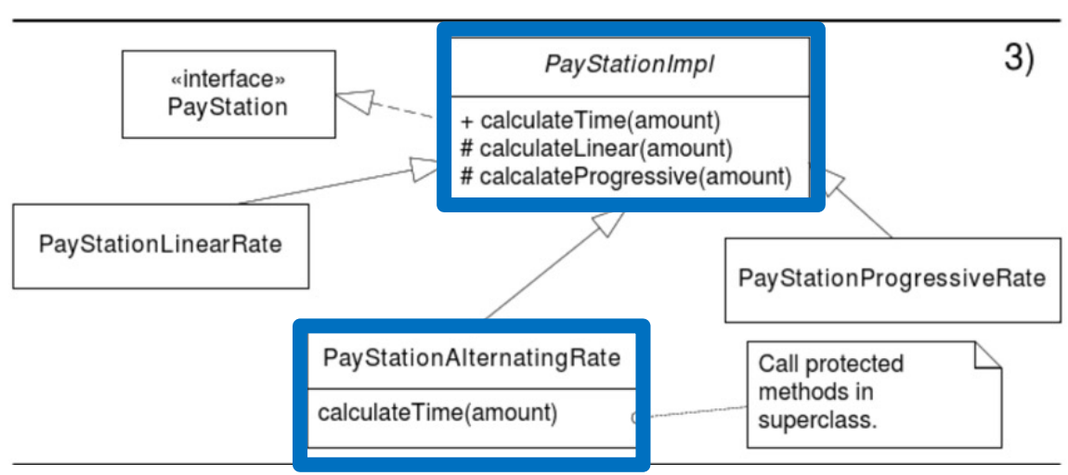

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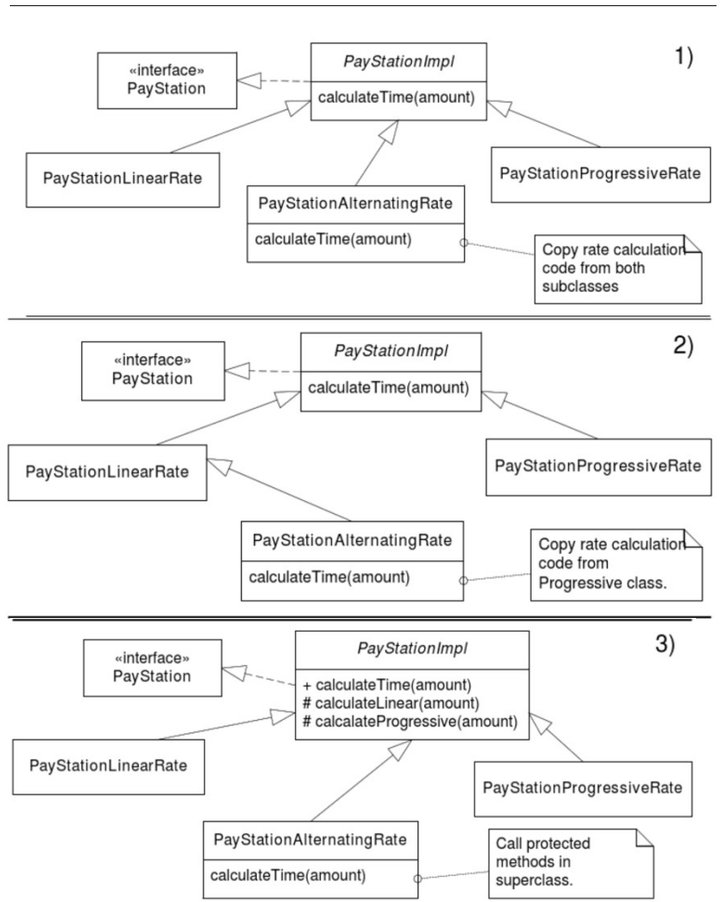


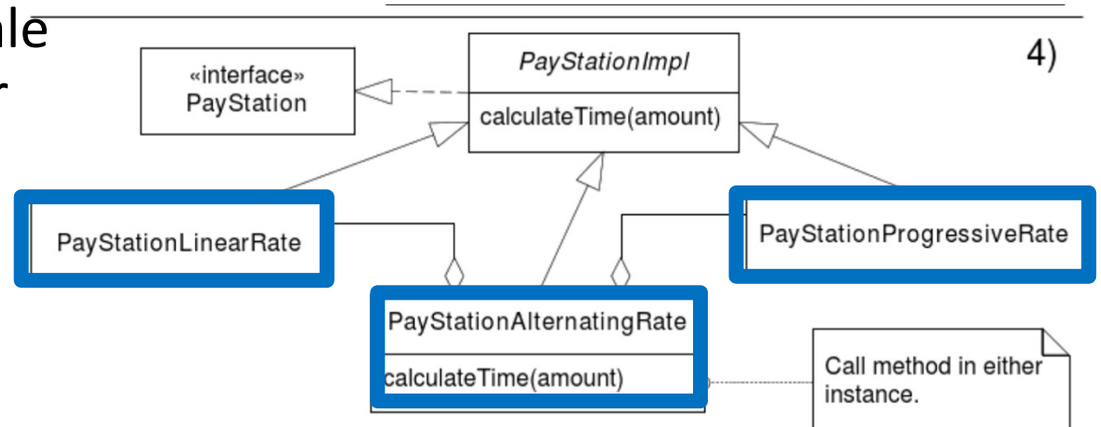

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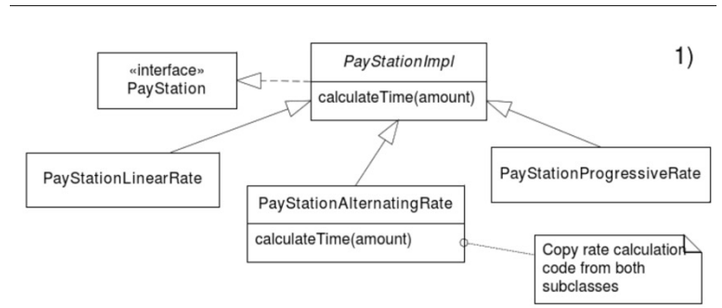
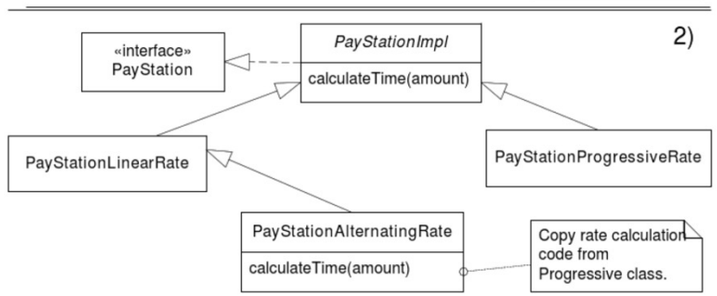
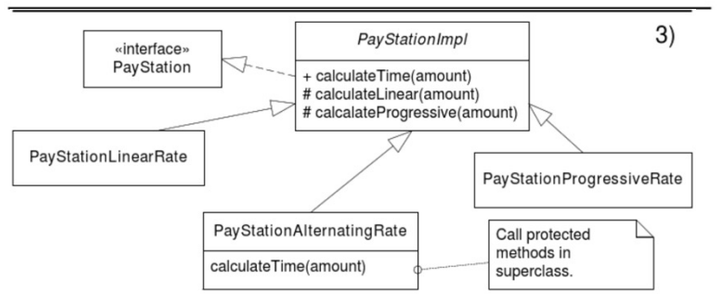
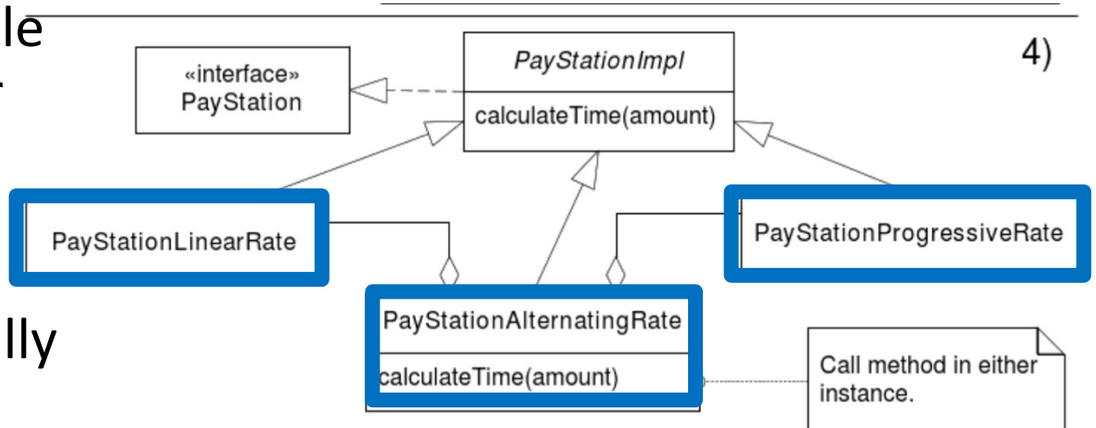
4. Pay stations within pay station
   - Avoids duplication, but is conceptually confusing



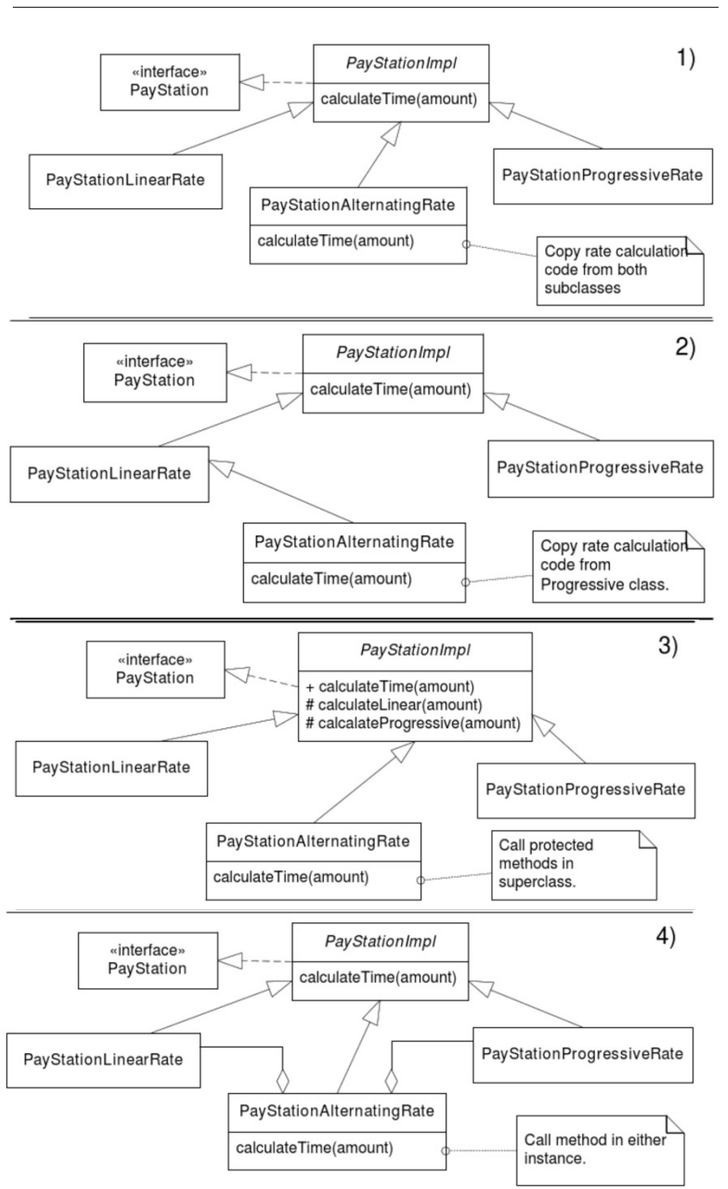



# Polymorphic Solution Proposal

How are our polymorphic options?
→ Not great!

Let's return to compositional design



# Compositional + Parametric Proposal

Option: Conditional for delegating to a rate strategy

```
public class PayStationImpl implements PayStation {
  [...]
  /** the strategy for rate calculations */
  private RateStrategy rateStrategyWeekday;
  private RateStrategy rateStrategyWeekend;

  /** Construct a pay station. */
  public PayStationImpl( RateStrategy rateStrategyWeekday,
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  }
  public void addPayment( int coinValue )
          throws IllegalCoinException {
    [...]
    if ( isWeekend() ) {
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  }
  [...]
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Testing AlphaTown:

```
public void setUp() {
  ps = new PayStationImpl( new LinearRateStrategy(),
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Testing AlphaTown:

```java
public void setUp() {
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- Modifies code
- Strange constructor for AlphaTown and BetaTown (weak cohesion)
- Adds pay station responsibility

# Compositional Proposal

Recall 3-1-2 process:

**(3): Identify behavior that varies**

**(1): State a responsibility that covers the behavior and express it as an interface**

**(2): Compose the behavior by delegating**

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→ Implement GammaTown behavior by combining existing rate calculations

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→ Implement GammaTown behavior by combining existing rate calculations

→ Proposal: A "coordinator" delegates rate calculation to specialized "workers" (already-implemented rate calculations)

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**Key Point: Object collaborations define compositional designs**

*When designing software compositionally, you make objects collaborate to achieve complex behavior.*

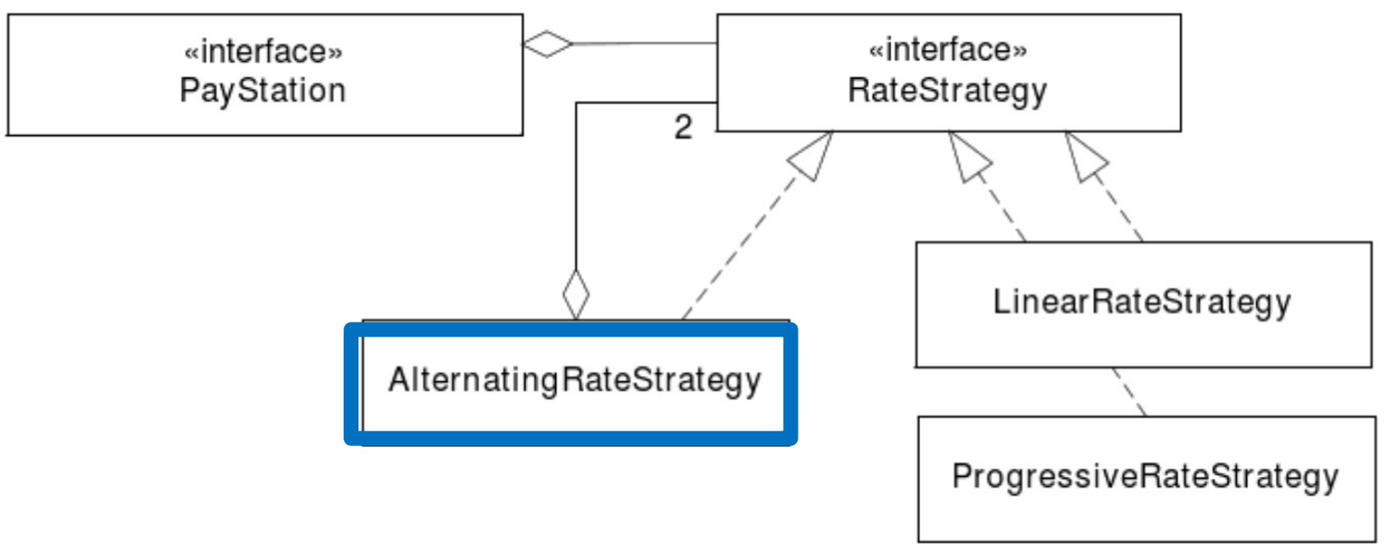


Figure 11.3: Rate calculation as a combined effort.

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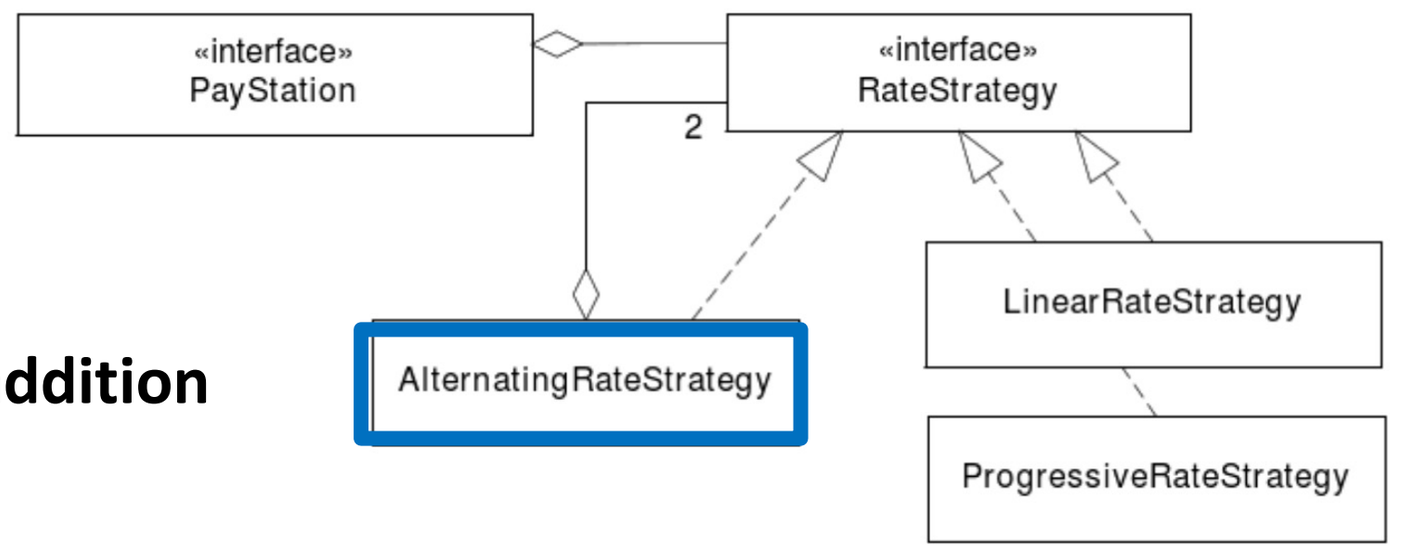
Change by **addition**

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# TDD: Compositional Design

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AlphaTown

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GammaTown

| **Unit under test: Rate calculation** | |
|---|---|
| Input | Expected output |
| pay = 500 cent, day = Monday<br>pay = 500 cent, day = Sunday | 200 min.<br>150 min. |

# TDD: Compositional Design

For TDD, how do we write a test for this?

Day of the week is not a parameter in the pay station or rate calculation!

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GammaTown

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| pay = 500 cent, day = Sunday | 150 min. |

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Suppose we define:

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private boolean isWeekend() {
  Date d = new Date();
  Calendar c = new GregorianCalendar();
  c.setTime(d);
  int dayOfWeek = c.get(Calendar.DAY_OF_WEEK);
  return ( dayOfWeek == Calendar.SATURDAY
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Do we need to run this on different days to test?

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External resources are a more general problem that we will discuss more later; for now, we'll assume manual testing

# Compositional Design

AlternatingRateStrategy.java

```java
package paystation.domain;

import java.util.*;

/** A rate strategy that uses the State pattern to vary behavior
    according to the state of the system clock: a linear rate
    during weekdays and a progressive rate during weekdends.
*/
public class AlternatingRateStrategy implements RateStrategy {
  private RateStrategy
    weekendStrategy, weekdayStrategy, currentState;
  public AlternatingRateStrategy( RateStrategy weekdayStrategy,
                                  RateStrategy weekendStrategy ) {
    this.weekdayStrategy = weekdayStrategy;
    this.weekendStrategy = weekendStrategy;
    this.currentState = null;
  }
  public int calculateTime( int amount ) {
    if ( isWeekend() ) {
      currentState = weekendStrategy;
    } else {
      currentState = weekdayStrategy;
    }
    return currentState.calculateTime( amount );
  }
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Decide **state** of RateStrategy

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Delegate calculation

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This is the **State** design pattern

Decide **state** of RateStrategy

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Delegate calculation

# Compositional Design: Analysis

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TestAlternatingRate.java

```java
public void setUp() {
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# Compositional Design: Analysis

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- Increased number of objects

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# State Pattern

**State pattern:** allow an object to alter its behavior when its internal state changes

**[11.1] Design Pattern: State**

**Intent** Allow an object to alter its behavior when its internal state changes.

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**Solution** Describe the responsibilities of the dynamically varying behavior in an interface and implement the concrete behavior associated with each unique state in an object, the state object, that implements this interface. The context object delegates to its current state object. When internal state changes occur, the current state object reference is changed to refer to the corresponding state object.

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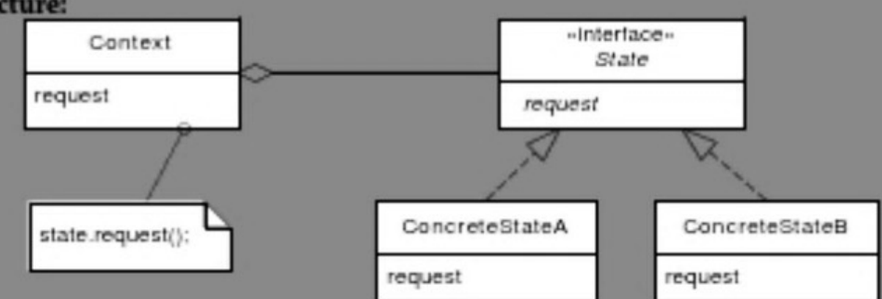


**Roles** **State** specifies the responsibilities and interface of the varying behavior associated with a state, and **ConcreteState** objects define the specific behavior associated with each specific state. The **Context** object delegates to its current state object. The state object reference is changed whenever the context changes its internal state.

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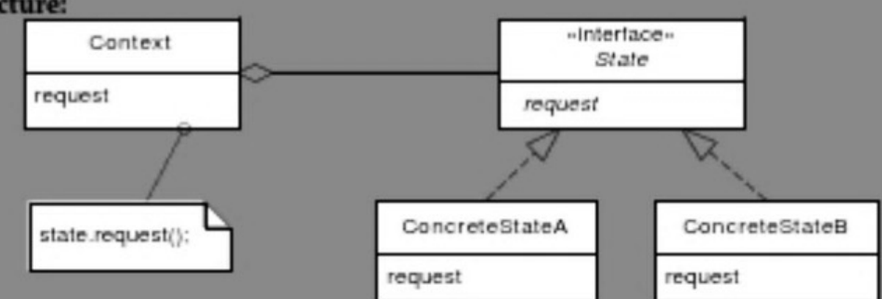


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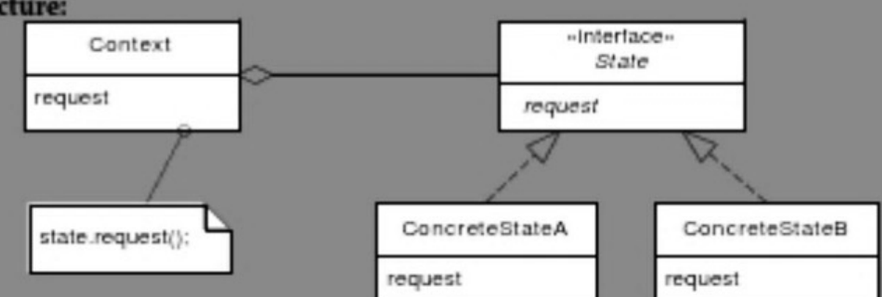


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# State Pattern

**State pattern:** allow an object to alter its behavior when its internal state changes

- **Context** object delegates requests to the state object
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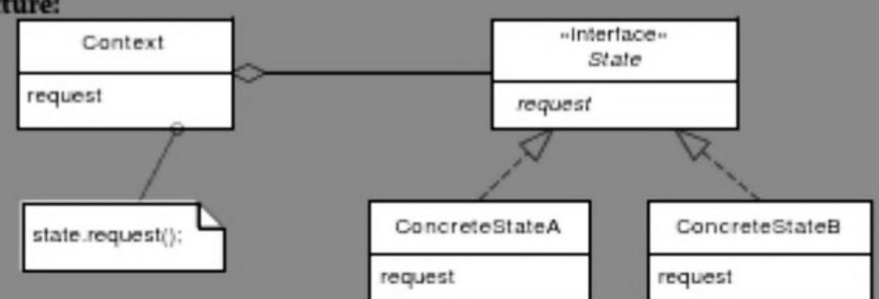


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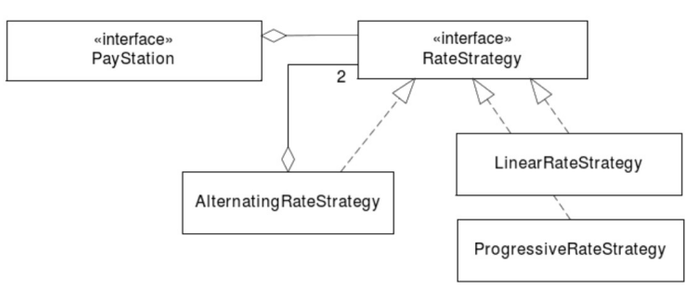


Figure 11.3: Rate calculation as a combined effort.

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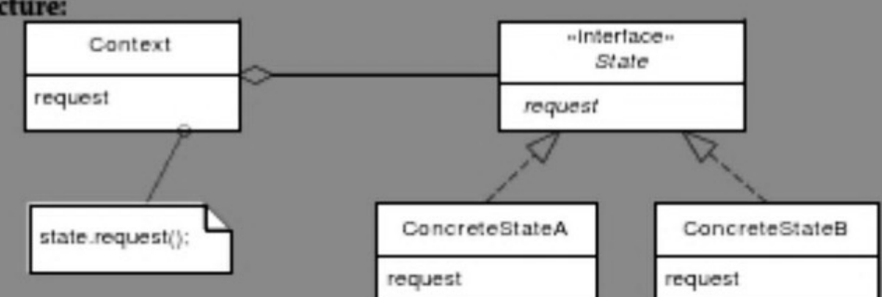


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Same structure as Strategy pattern!

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PatternCraft: State
https://www.youtube.com/watch?v=yZt7mUVDijU&list=PL8B19C3040F6381A2&index=1

Next Time: How do we test the alternating rate? → Test Stubs