CS 130 SOFTWARE ENGINEERING

DESIGN PATTERNS

TEMPLATE METHOD, STATE
FLYWEIGHT

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CLARIFICATION

- I want to emphasize that all teaching materials (assignments, quizzes, lab section materials) are designed by the teaching team together. Each TA takes turns to be in charge of grading, etc.
- Office hours are resources / time reserved for you. Please leverage the time and if the time does not work, please stop by any time.

AGENDA

- Façade
- Template Method
- State
- Flyweight

RECAP

- Singleton ensures a single object creation.
- Command decouples a receiver object's actions from invokers.
- Adaptor adapts legacy code to a target interface.

REAL WORLD APPLICATIONS

- Strategy
  - Everywhere actually. E.g. Comparable in Java
- Factory Method:
  - Everywhere actually. E.g. A graphical chart object construction, dynamic allocation based on resources, a database connection with different DB backends.
- Abstract Factory
  - E.g. A dynamic allocation of VM with different, OS, applications, memory needs, etc. (Google Cloud's Docker)
  - E.g. Kubernetes (Google's coordinated cluster with multiple VMs)

REAL WORLD APPLICATIONS

- Observer
  - Publish and subscribe, most GUI object event handling (mouse click etc)
- Mediator
  - Lots and lots of networking protocol implementation, coordination protocols

REAL WORLD APPLICATIONS

- Singleton
  - So many times, a thread pool, a resource pool, a logger object
- Command
  - Transactional DB operation with “undo” and “failure recovery mode”, etc.
- Adaptor
  - Most legacy code reuse with a new interface. Typically called as a “wrapper” code

TEMPLATE METHOD

Starbuzz Coffee Barista Training Manual

Baristas! Please follow these recipes precisely when preparing Starbuzz beverages.

Starbuzz Coffee Recipe

(1) Boil some water
(2) Brew coffee in boiling water
(3) Pour coffee in cup
(4) Add sugar and milk

Starbuzz Tea Recipe

(1) Boil some water
(2) Steep tea in boiling water
(3) Pour tea in cup
(4) Add lemon

All recipes are Starbuzz Coffee trade secrets and should be kept strictly confidential.

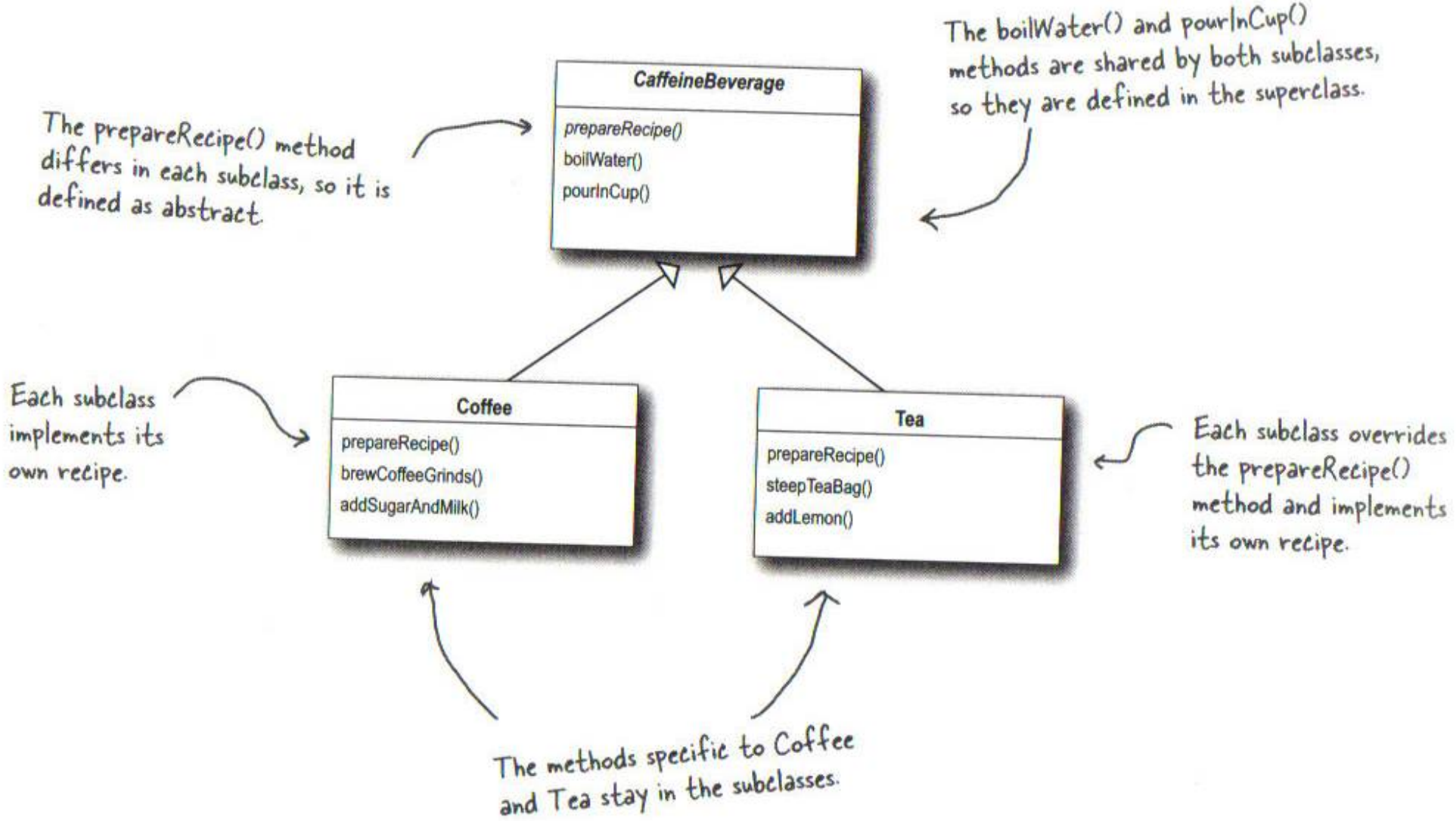
The recipe for coffee looks a lot like the recipe for tea, doesn't it?

MOTIVATION FOR TEMPLATE METHOD

- Varying objects want to do similar things but slightly different ways
- The overall work flow is similar
- Certain steps are identical but certain steps differ

NOW LET'S TAKE A LOOK AT SKELETON CODE

- Handout-DesignPatternSkeletons


CaffeineBeverage
prepareRecipe()
boilWater()
pourInCup()
The prepareRecipe() method differs in each subclass, so it is defined as abstract.
The boilWater() and pourInCup() methods are shared by both subclasses, so they are defined in the superclass.
Coffee
prepareRecipe()
brewCoffeeGrinds()
addSugarAndMilk()
Tea
prepareRecipe()
steepTeaBag()
addLemon()
Each subclass implements its own recipe.
Each subclass overrides the prepareRecipe() method and implements its own recipe.
The methods specific to Coffee and Tea stay in the subclasses.

ABSTRACTED RECIPE METHOD

```
void prepareRecipe() {
    boilWater();
    brew();
    pourInCup();
    addCondiments();
}
```

ABSTRACT BASE CLASS

```
public abstract class CaffeineBeverage {
    final void prepareRecipe() {
            boilWater();
            brew();
            pourInCup();
            addCondiments();
    }
    abstract void brew();
    abstract void addCondiments();
    void boilWater() {
            System.out.println(“Boiling Water”);
    }
    void pourInCup() {
            System.out.println("Pouring into cup");
    }
}
```

COFFEE AND TEA IN TERMS OF THE ABSTRACT CAFFEINE CLASS

```
public class Coffee extends CaffeineBeverage {
    public void brew() {
        System.out.println("Dripping Coffee through filter");
    }
    public void addCondiments() {
    System.out.println("Adding Sugar and Milk");
    }
}

public class Tea extends CaffeineBeverage {
    public void brew() {
        System.out.println("Steeping the tea");
    }
    public void addCondiments() {
        System.out.println("Adding Lemon");
    }
}
```

TEMPLATE METHOD PATTERN DEFINED

The Template Method Pattern defines the skeleton of an algorithm in a method, deferring some steps to subclasses. Template Method lets subclasses redefine certain steps of an algorithm without changing the algorithm's structure.

THINK PAIR SHARE (HAND OUT)

(A)The following is a code snippet using Swing frame. Where can you find the use of a template method pattern?

(B) The following program is a sorting program for Ducks. Where can you find the use of a template method pattern?

THINK PAIR SHARE

- What is the difference between Template Method and Strategy?

TEMPLATE METHOD VS. STRATEGY

- Template Method defines the outline of algorithms and let subclasses do some of the work.
- Template Method keeps control over the algorithm's structure.
- Template Method puts all duplicated code into a super class and subclasses share the common code.

- Strategy defines a family of algorithms and makes them interchangeable.
- Strategy does not control the algorithm's structure.
- Strategy uses composition so it's more flexible to switch with a new strategy.

STATE

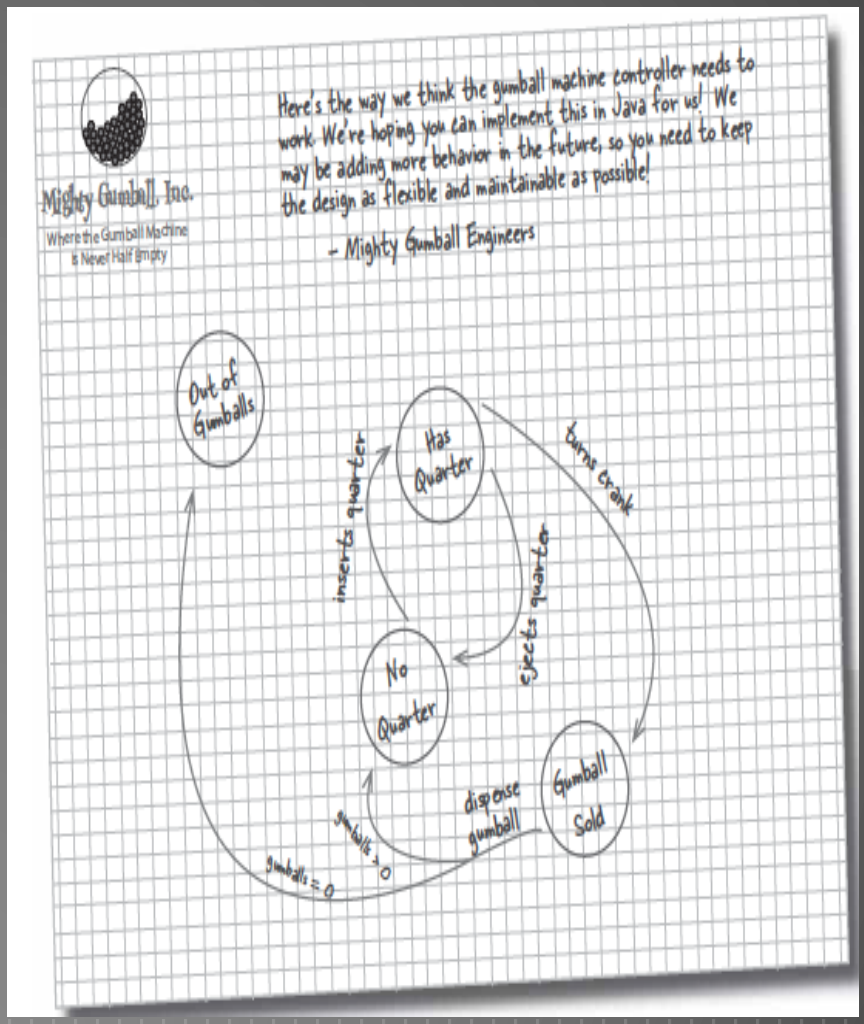
EXAMPLE: GUMBALL MACHINE

Gumball Machine inc. needs a JAVA application for controlling Gumball Machine

Gumball Machine requirements are represented as a State Transition diagram

STATE TRANSITION REQUIREMENTS

- States :
- No Quarter
- Has Quarter
- Gumball Sold
- Out Of Gumballs
-



TRANSFORMING REQUIREMENTS INTO CODE

Team transform the state diagram using following steps:

Step 1: Gather the states

Step 2: Create an instance variable to hold the current state & define values for each state

Step 3: Gather up all the actions that can happen in the system

Step 4: Create a class that acts as state machine & map each action to a method

NAÏVE DESIGN

```
public class GumballMachine {

    final static int SOLD_OUT = 0;
    final static int NO_QUARTER = 1;
    final static int HAS_QUARTER = 2;
    final static int SOLD = 3;

    int state = SOLD_OUT;
    int count = 0;
```

NAÏVE DESIGN

```
public GumballMachine(int count) {
        this.count = count;
        if (count > 0) {
                state = NO_QUARTER;
        }
}
public void insertQuarter() {
        if (state == HAS_QUARTER) {
                System.out.println("You can't insert another quarter");
        } else if (state == NO_QUARTER) {
                state = HAS_QUARTER;
                System.out.println("You inserted a quarter");
        } else if (state == SOLD_OUT) {
                System.out.println("You can't insert a quarter, the machine is s
        } else if (state == SOLD) {
System.out.println("Please wait, we're already giving you a gumball");
        }
```

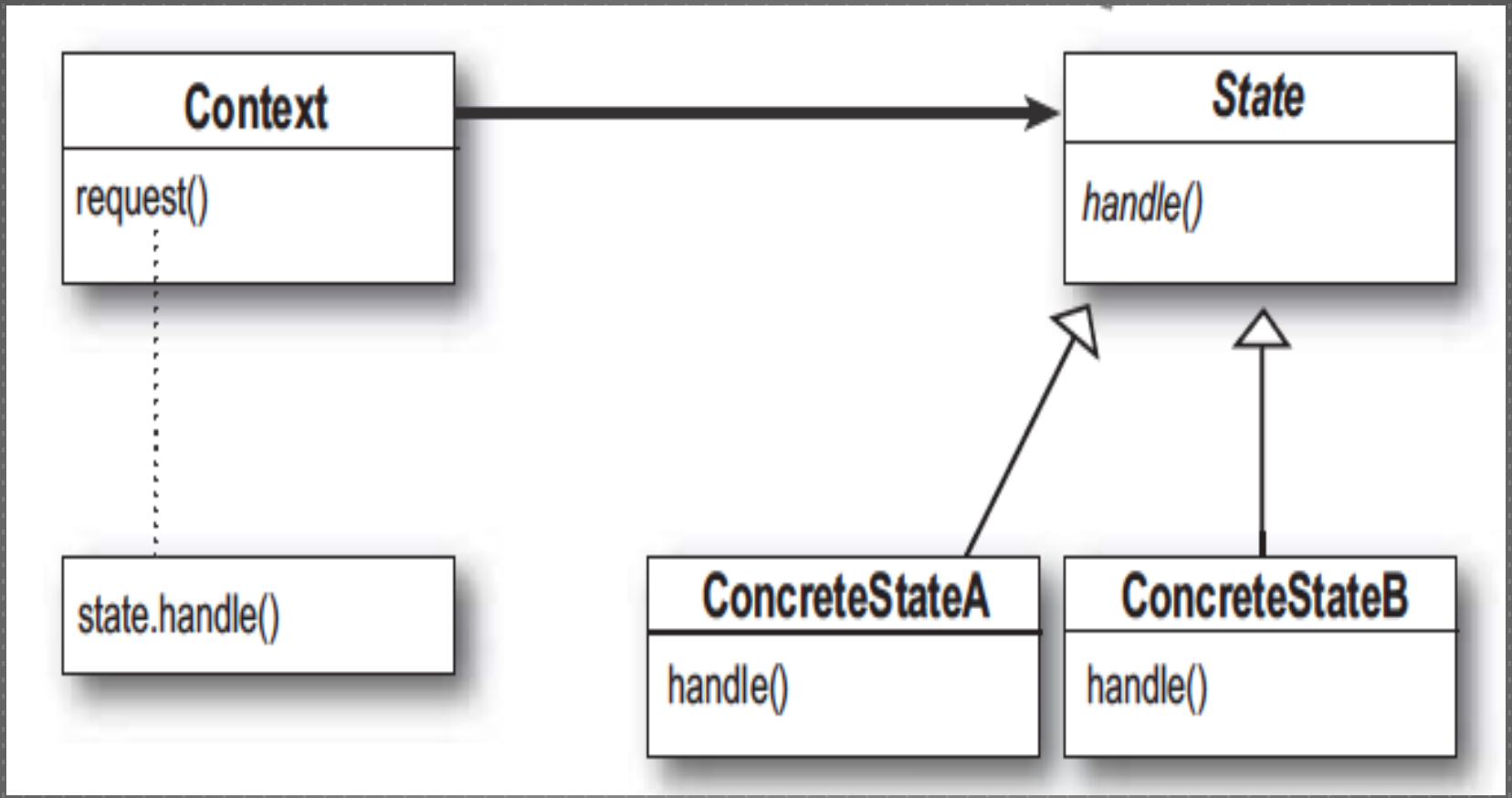
MOTIVATION FOR STATE

- You'd like to code a complex state transition
- You'd like to not forget "defining state transitions" for each state and check this at compile time!

STATE PATTERN MECHANICS

- Encapsulate the varying behavior
- Create a new class for every State
- Localize the behavior for each State
- Adding new State => adding a new class
- Handling new requirements is easy

CLASS DIAGRAM



```
public class GumballMachine {
        State soldOutState;
        State noQuarterState;
        State hasQuarterState;
        State soldState;
        State state = soldOutState;
        int count = 0;
        public GumballMachine(int numberGumballs) {
                soldOutState = new SoldOutState(this);
                noQuarterState = new NoQuarterState(this);
                hasQuarterState = new HasQuarterState(this);
                soldState = new SoldState(this);
                this.count = numberGumballs;
                if (numberGumballs > 0) {
                        state = noQuarterState;
                }
        }
        public void insertQuarter() {
                state.insertQuarter();
        }
        public void ejectQuarter() {
                state.ejectQuarter();
        }
        public void turnCrank() {
                state.turnCrank();
```

```
public class SoldState implements State {
        GumballMachine gumballMachine;
        public SoldState(GumballMachine gumballMachine) {
            this.gumballMachine = gumballMachine;
        }
          public void insertQuarter() {
                    System.out.println("Please wait, we're already giving you a gumball");
          }
          public void ejectQuarter() {
                    System.out.println("Sorry, you already turned the crank");
          }
          public void turnCrank() {
                    System.out.println("Turning twice doesn't get you another gumball!");
          }
          public void dispense() {
                    gumballMachine.releaseBall();
                    if (gumballMachine.getCount() > 0) {
                              gumballMachine.setState(gumballMachine.getNoQuarterState());
                    } else {
                              System.out.println("Oops, out of gumballs!");
                              gumballMachine.setState(gumballMachine.getSoldOutState());
                    }
          }
          public String toString() {
                    return "dispensing a gumball";
```

IMPLEMENTING STATE PATTERN

- Define a State interface
- Implement a State class for every state of the machine
- Eliminate the conditional code by delegating the work to the State class

PROS AND CONS

- Encapsulates all the behavior of a State in one object
- Helps avoiding inconsistent States Changes

- Make the code bulky and increases the number of objects
- Class Explosion problem
- Brittle Interfaces

	Action A	…	ActionD
State 1	X		
State 2			

```
State1 implements State {

   actionA() {XXX; }
   actionB() {}
   actionC() {}
   actionD() {}
}
```

THE STATE PATTERN

The State Pattern allows an object to alter its behavior when its internal state changes. The object will appear to change its class.

NOW LET'S TAKE A LOOK AT SKELETON CODE

- Handout-DesignPatternSkeletons

THINK-SHARE-PAIR QUESTION 1

How is the Strategy Pattern different from the State Pattern?

THINK-SHARE-PAIR QUESTION 1

- They share similarity in declaring a field state and delegating work to the field. State is a specific case of using strategy, where actions have consequences on the machine's state.
- Strategy Pattern is a flexible alternative to subclassing, with strategy you can change the behavior by composing with a different object.
- State Pattern is an alternative to putting lots of conditions; by encapsulating the behavior within state objects, you can simply change the state object in context to change its behavior

MATCH EACH PATTERN WITH ITS DESCRIPTION

1. State
2. Strategy
3. Template Method

A. Encapsulate interchangeable behaviors and use delegation to decide which behavior to use
B. Subclasses decide how to implement steps in an algorithm
C. Encapsulate state-basted behavior and delegate behavior to the current state

QUESTION 2

Transform the TV Remote Application using the State Design Pattern

QUESTION 3

1. Identify the class the Context class
2. Identify the State Interface
3. Identify the ConcreteState classes

RECAP: TEMPLATE METHOD

- Keyword: workflow.
- Intent: to keep the structure of an algorithm / workflow constant, while allowing subclasses to vary certain steps.
- abstract class A {
- abstract public void varyingStep();
- void commonStep {// write code there }
- final void workflow { commonStep(); varyingStep()}
- class B extends A { void varyingStep(){…}}

RECAP: STATE

- Intent: code a state transition diagram
- Information Hiding Principle:
  - What are the changes are expected to happen in the future? Adding a new State
  - What are the changes that are considered less likely happen? Adding a new Transition
- What are the benefits of using a state design pattern?
  - Remove conditional statements
  - Ensuring that each state takes care of all transitions are done by "compile time check"

- Interface State {
- void transition1(); void transition2();
- }
- class State1 implements State{
- Context context;
- Public State1 (Context c) { context=c; }
  - void transition1() { // do some action,
    - context.setState(context.getState2()}.
  - void transition2() {…}
- }
- class Context {
  - State currentState; State state1= new State1(this); State state2=new State2(this);
  - void transition1() { **currentState.transition1**(); }
  - State getState1() { return state1}; State getState2() {return state2;}

FLYWEIGHT PATTERN

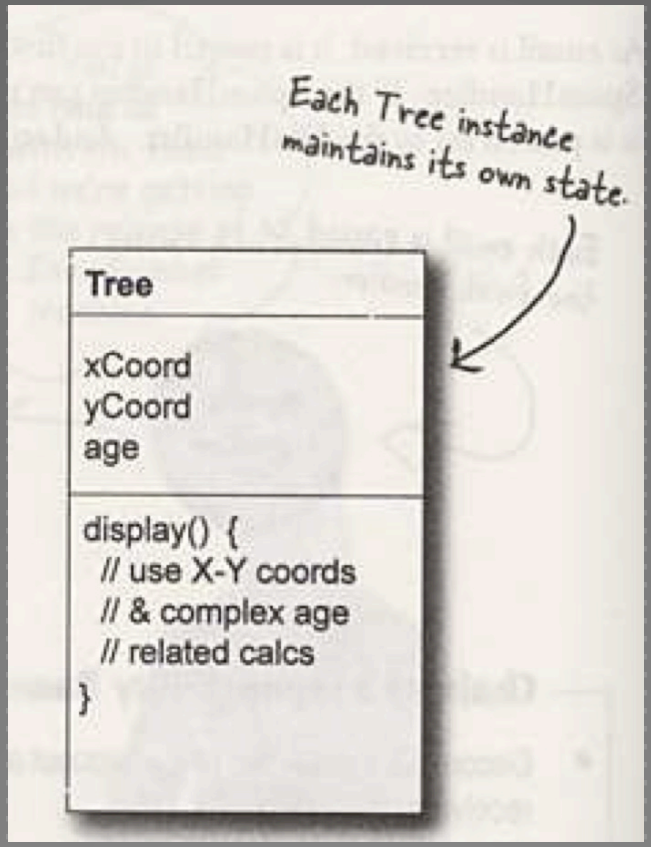
THE SCENARIO

- You want to add trees to a landscape design application
  - Trees are pretty dumb; they have x-y locations, they can draw themselves dynamically (depending on an age attribute)
  - A user might want to add lots and lots of trees
- A user of your application is complaining that, when he creates large groves of trees, the app gets sluggish
  - Yikes! There are THOUSANDS of tree objects!
- When you have tons of objects that are basically the same
  - Create a single instance of the object
  - A single client object that manages the state of all of those objects

MOTIVATION FOR FLYWEIGHT

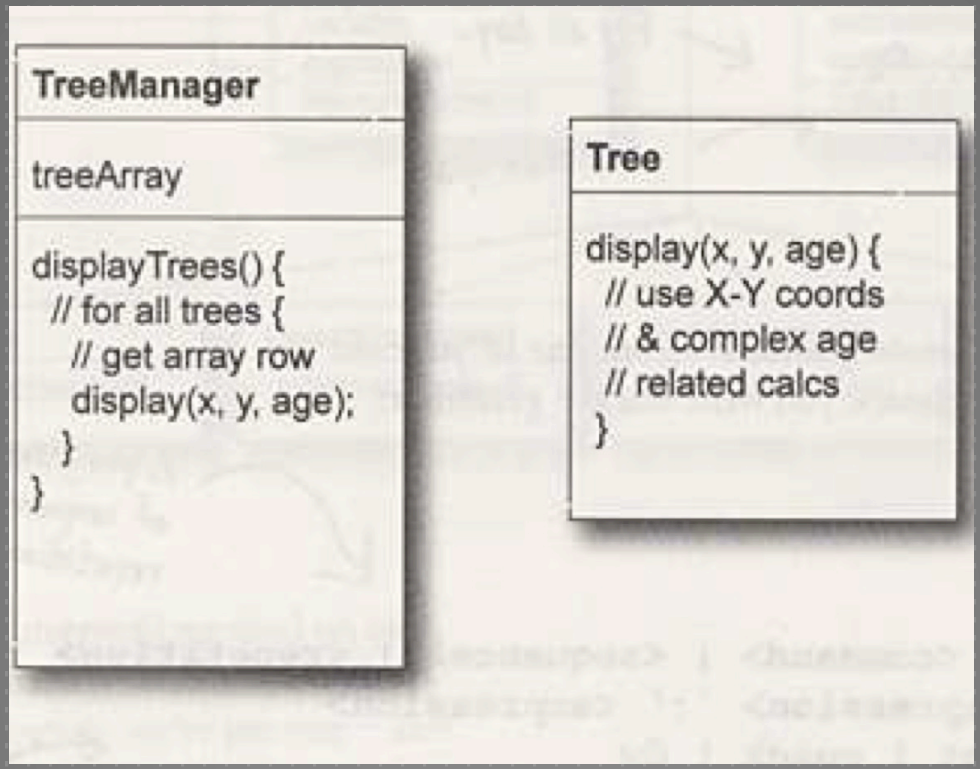
- Save resources by sharing objects when one instance can be used to provide many virtual instances
- Never reconstruct the expensive object
- Key mechanism: Separate the context of using the expensive object as a "Context"

WITHOUT FLYWEIGHT

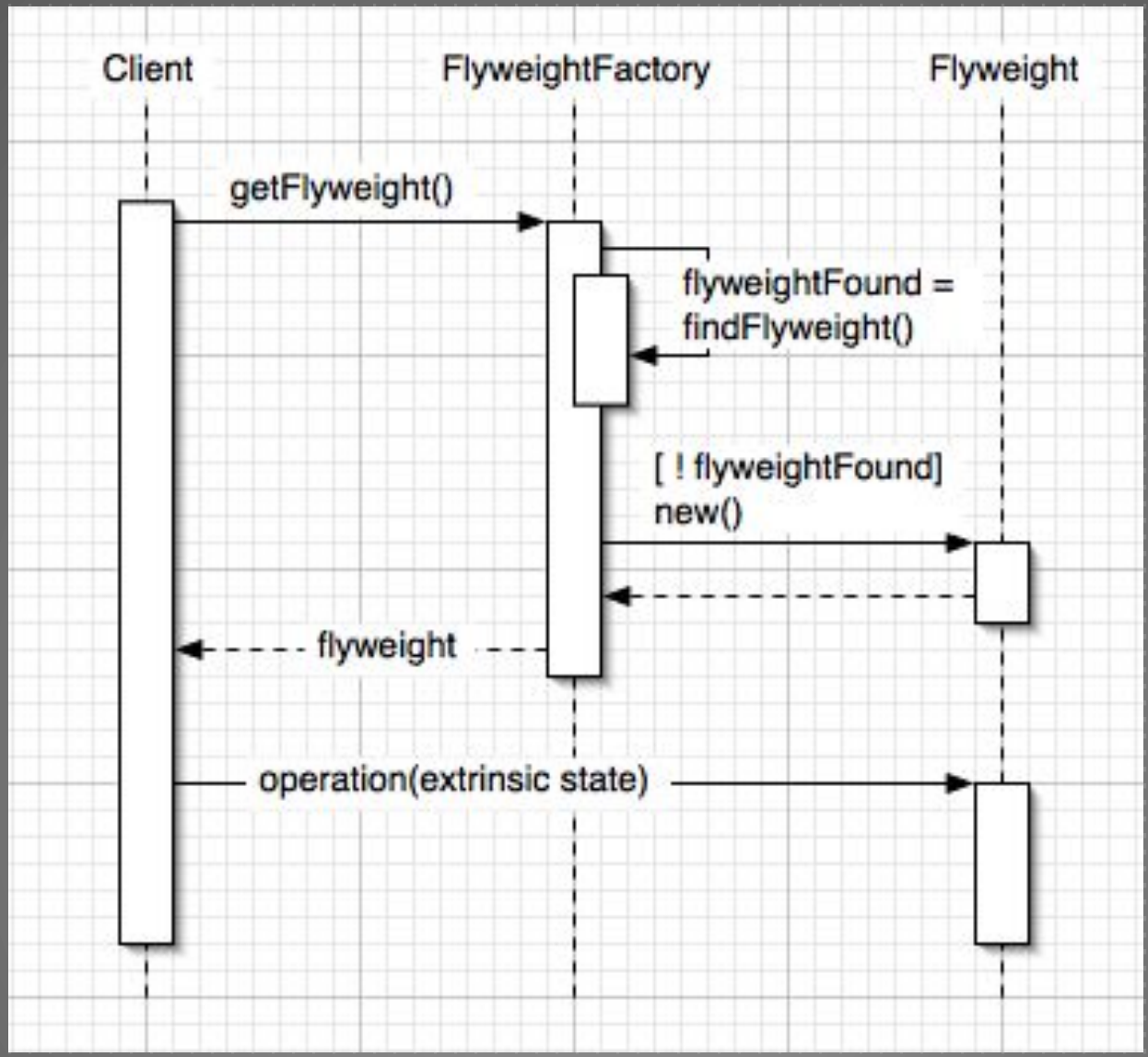


WITH FLYWEIGHT

- Have only one instance of Tree
- A client object maintains the state of All trees.



THE FLYWEIGHT SEQUENCE DIAGRAM



ANOTHER EXAMPLE

```
class ColorBox extends Canvas implements Runnable {
  private int    pause;
  private Color  curColor = getColor();
  private static Color[]  colors = { Color.black, Color.blue, Color.cyan,
    Color.darkGray, Color.gray, Color.green, Color.lightGray, Color.red,
    Color.magenta, Color.orange, Color.pink, Color.white, Color.yellow };

  public ColorBox( int p ) {
    pause = p;
    new Thread( this ).start();
  }
  private static Color getColor() {
    return colors[ (int)(Math.random() * 1000) % colors.length ];
  }
```

```
  public void run() {
    while (true) {
      curColor = getColor();
      repaint();
      try { Thread.sleep( pause ); } catch( InterruptedException e ) { }
  } }
  public void paint( Graphics g ) {
    g.setColor( curColor );
    g.fillRect( 0, 0, getWidth(), getHeight() );
} }

public class ColorBoxes {
  public static void main( String[] args ) {
    int size = 8, pause = 10;
    if (args.length > 0) size  = Integer.parseInt( args[0] );
    if (args.length > 1) pause = Integer.parseInt( args[1] );
    Frame f = new FrameClose( "ColorBoxes - 1 thread per ColorBox" );
    f.setLayout( new GridLayout( size, size ) );
    for (int i=0; i < size*size; i++) f.add( new ColorBox( pause ) );
    f.setSize( 500, 400 );
    f.setVisible( true );
} }
```

PROS AND CONS

- Reduces the number of object instances at runtime
- Centralizes state for many virtual objects into a single location
- Many instances must be controlled similarly
- Once you implemented Flyweight, a single logical instance will not be able to behave independently from other instances

THE FLYWEIGHT PATTERN

The Flyweight Pattern allows one instance of a class can be reused to provide many virtual instances.

RECAP

- Template Method allows to set a common workflow where sub steps may vary.
- State allows to encode complex state transitions.
- Flyweight allows to share common resources by separating usage contexts from used objects.

RECAP : OBSERVER AND MEDIATOR

DIFFERENCE BETWEEN OBSERVER AND MEDIATOR

- Both are communication abstractions
- Observer 1:n relationship between subject and observers.
- It's easy to add a new observer in Observer.
- Mediator abstracts n:n relationship among multiple objects.
- Every object only knows about Mediator and trusts Mediator to call other objects that I want to communicate.

LET'S CONSIDER MEDIATOR EXAMPLE

```
class Mediator {
private boolean slotFull = false;
  private int number;
  public synchronized void storeMessage(
int num ) {
    // no room for another message
    while (slotFull == true) {
      try {
        wait();
      }
      catch (InterruptedException e ) { }
    }
    slotFull = true;
    number = num;
    notifyAll();
  }
```

```
public synchronized int
retrieveMessage() {
    // no message to retrieve
    while (slotFull == false)
      try {
        wait();
      }
      catch (InterruptedException e ) {
}
    slotFull = false;
    notifyAll();
    return number;
  }
}
```

```
class Consumer extends Thread {
private Mediator med;
  private int    id;
  private static int num = 1;
  public Consumer( Mediator m ) {
    med = m;
    id = num++;
  }
  public void run() {
    while (true) {
      System.out.print("c" + id + "-" + med.retrieveMessage() + "  ");
    }
  }
}
```

```
class Producer extends Thread {
  // 2. Producers are coupled only to the Mediator
  private Mediator med;
  private int    id;
  private static int num = 1;
  public Producer( Mediator m ) {
    med = m;
    id = num++;
  }
  public void run() {
    int num;
    while (true) {
      med.storeMessage( num = (int)(Math.random()*100) );
      System.out.print( "p" + id + "-" + num + "  " );
    }
  }
}
```

```
class MediatorDemo {
  public static void main( String[] args ) {
    Mediator mb = new Mediator();
    new Producer( mb ).start();
    new Producer( mb ).start();
    new Consumer( mb ).start();
    new Consumer( mb ).start();
    new Consumer( mb ).start();
    new Consumer( mb ).start();
  }
}
```

QUESTIONS?