DESIGN PATTERNS

COURSE 4

PREVIOUS COURSE

- **Creational Patterns**
  - Factory Method defines an interface for creating objects, but lets subclasses decide which classes to instantiate
  - Abstract Factory provides an interface for creating families of related objects, without specifying concrete classes
  - Builder separates the construction of a complex object from its representation, so that the same construction process can create different representation
  - Prototype specifies the kind of objects to create using a prototypical instances
  - Singleton ensures that a class has only one instance, and provides a global point of access to that instance

CONTENT

- **Structural patterns**
  - Adapter
  - Bridge
  - Façade
  - Flyweight
  - Proxy
  - Composite
  - Decorator

STRUCTURAL PATTERNS

- **Help identify and describe relationships between entities**
- **Address how classes and objects are composed to form large structures**
  - Class-oriented patterns use inheritance to compose interfaces or implementations
  - Object-oriented patterns describe ways to compose objects to realize new functionality, possibly by changing the composition at run-time
- **Example**
  - Proxy in distributed programming
  - Bridge in JDBC drivers

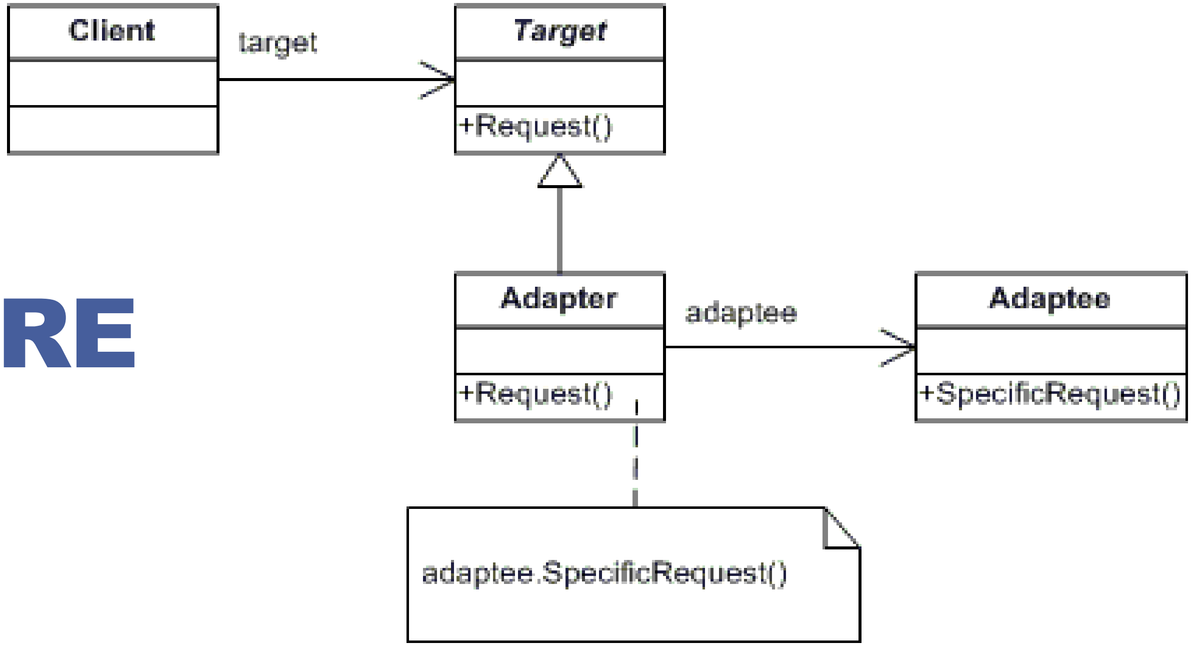
STRUCTURAL PATTERNS

- **<u>Adapter</u>**
  - interface converter
- **<u>Bridge</u>**
  - decouple abstraction from its implementation
- **<u>Façade</u>**
  - provide a unified interface to a subsystem
- **<u>Flyweight</u>**
  - using sharing to support a large number of fine-grained objects efficiently
- **Proxy**
  - provide a surrogate for another object to control access
- **Composite**
  - compose objects into tree structures, treating all nodes uniformly
- **Decorator**
  - attach additional responsibilities dynamically

ADAPTER

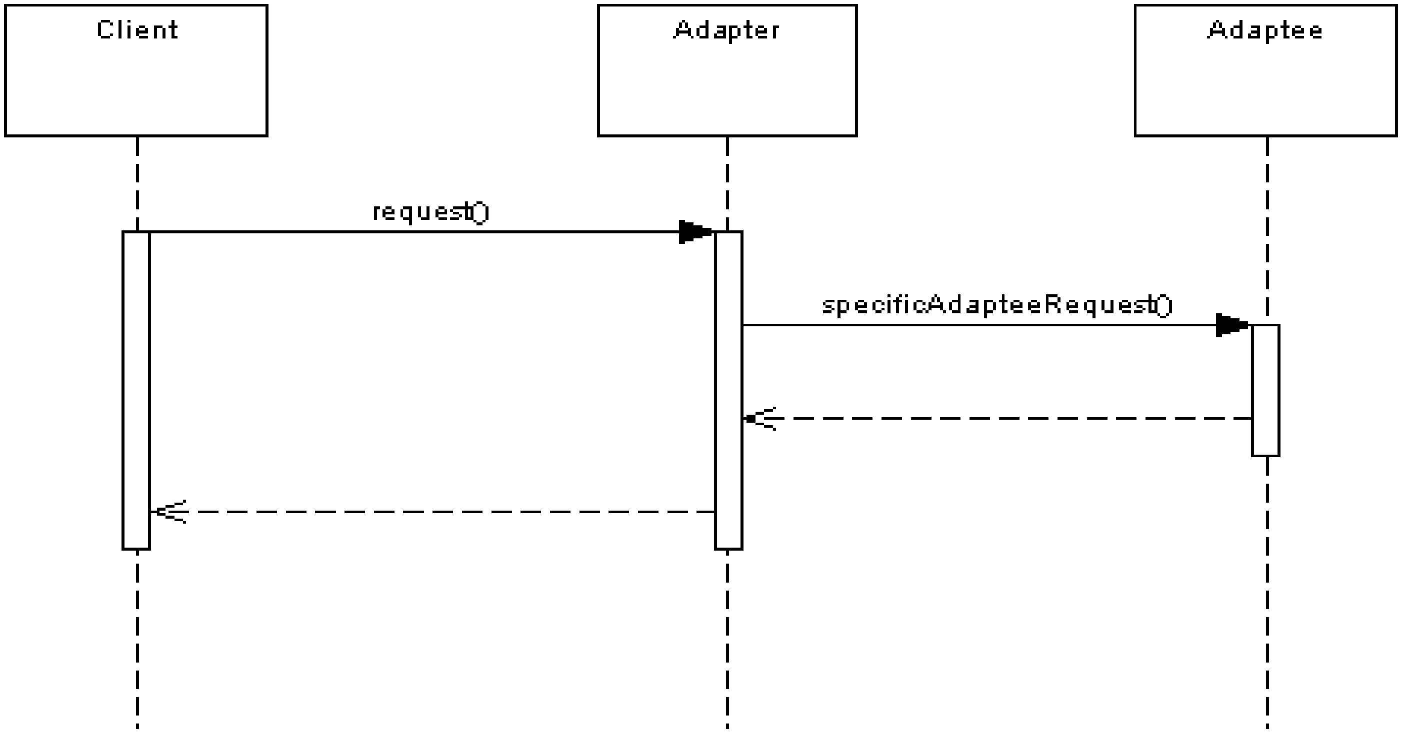
- **Indent**
  - Convert the interface of a class into another interface clients expect.
  - Adapter lets classes work together that couldn't otherwise because of incompatible interfaces.
  - Wrap an existing class with a new interface.
- **Also Known As**
  - Wrapper
- **Problem**
  - Sometimes a toolkit or class library can not be used because its interface is incompatible with the interface required by an application
  - We can not change the library interface, since we may not have its source code
  - Even if we did have the source code, we probably should not change the library for each domain-specific application

ADAPTER STRUCTURE



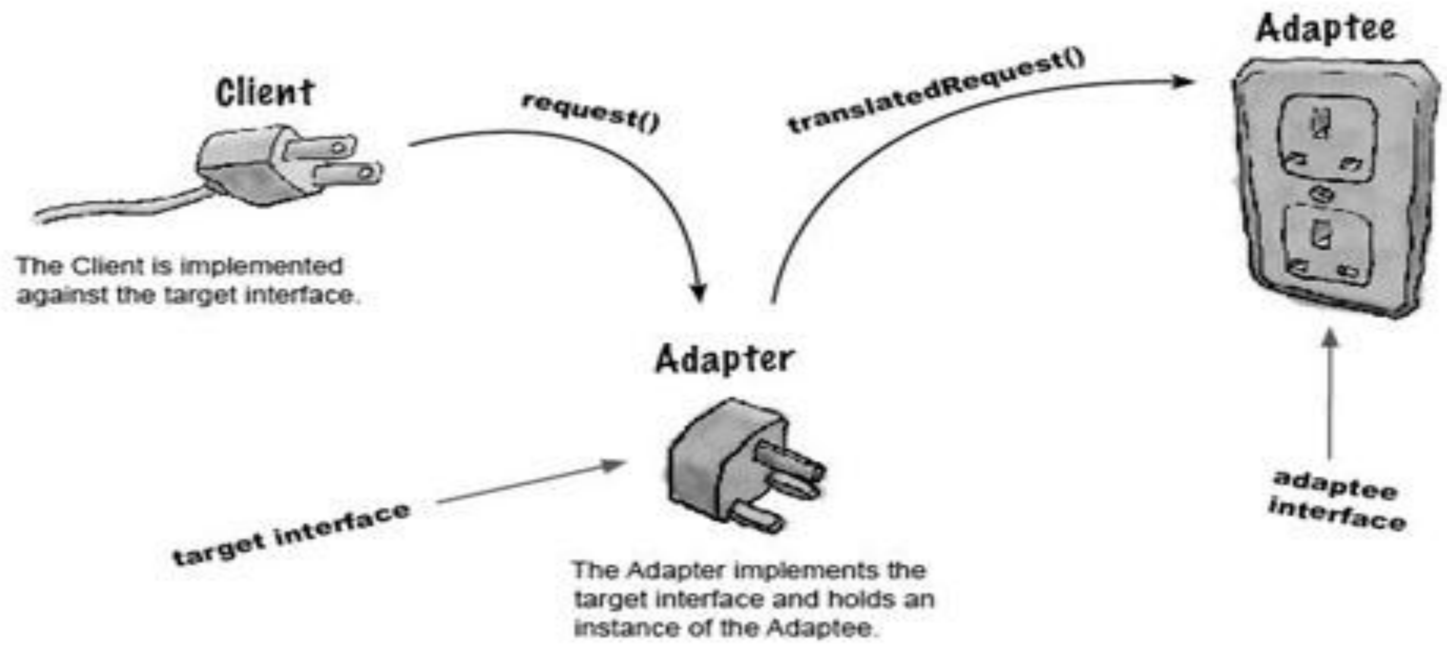
- **Target**
  - defines the domain-specific interface that Client uses.
- **Adapter**
  - adapts the interface Adaptee to the Target interface.
- **Adaptee**
  - defines an existing interface that needs adapting.
- **Client**
  - collaborates with objects conforming to the Target interface

ADAPTER.



- Client is concerned it's just calling the **request** method of the Target interface, which the Adapter has implemented.
- In the background however, the Adapter knows that to return the right result, it needs to call a different method, **specificAdapteeRequest**, on the Adaptee.

ADAPTER. EXAMPLE



- Eclipse plug-ins
  - For a particular object to contribute to the Properties view, adapters are used display the objects data.
  - The view itself doesn't need to know anything about the object the it is displaying properties for.

ADAPTER

- **Applicability**
  - Use the Adapter pattern when
    - You want to use an existing class, and its interface does not match the one you need
    - You want to create a reusable class that cooperates with unrelated classes with incompatible interfaces

- **2 types of implementations**
  - Class adapter (suitable for programming languages that allow multiple inheritance)
    - Concrete Adapter class
    - Unknown Adaptee subclasses might cause problem
    - Overloads Adaptee behavior
    - Introduces only one object
  - Object adapter
    - Adapter can service many different Adaptees
    - May require the creation of Adaptee subclasses and referencing those objects

ADAPTER

- **How much adapting should be done?**
  - Simple interface conversion that just changes operation names and order of arguments
  - Totally different set of operations

- **When to use adapter?**
  - you want to use an existing class, and its interface does not match the one you need
  - you want to create a reusable class that cooperates with unrelated or unforeseen classes, that is, classes that don't necessarily have compatible interfaces.
  - you have several subclasses and would like to adapt some of their operations. Use Object Adapter to adapt their parent class instead of adapting all subclasses

ADAPTER EXAMPLE 1

- **Consider that we have a third party library that provides print string functionality through PrintString class = adaptee**

```
public class PrintString {

    public void print(String s)  {
        System.out.println(s);
    }
}
```

- **Client deals with ArrayList<String> but not with string.**
  - provided a PrintableList interface that expects the client input.This is our target = target

```
public interface PrintableList {
    void printList(ArrayList<String> list);
}
```

  - Clients should see the printable list

ADAPTER EXAMPLE 1

- **Adapter pattern**

```
public class PrintableListAdapter implements PrintableList{

   public void printList(ArrayList<String> list) {

//Converting ArrayList<String> to String so that
// we can pass String to adaptee class
  String listString = "";

  for (String s : list) {
      listString += s + "\t";
  }

  // instantiating adaptee class
  PrintString printString=new PrintString();
  ps.print(listString);
 }
}
```

- **Client**

```
public class AdapterDesignPatternMain {

 public static void main(String[] args)
 {
  ArrayList<String> list=new
                        ArrayList<String>();
  list.add("one");
  list.add("two");
  list.add("three");
  PrintableList pl=new
                        PrintableListAdapter();
  pl.printList(list);
 }
}
```

ADAPTER EXAMPLE 2

- **We have the following 3th party library = adaptee**

```
public class CelciusReporter {

	double temperatureInC;

	public CelciusReporter() {
	}

	public double getTemperature() {
		return temperatureInC;
	}

	public void setTemperature(double temperatureInC) {
		this.temperatureInC = temperatureInC;
	}

}
```

ADAPTER EXAMPLE 2

- **Target interface**

```
public interface TemperatureInfo {

    public double getTemperatureInF();

    public void setTemperatureInF(double temperatureInF);

    public double getTemperatureInC();

    public void setTemperatureInC(double temperatureInC);

}
```

ADAPTER EXAMPLE 2

- **Propose a way to create an adapter using**
  - inderitance
  - composition

- **Hellper methos that allows transormation from celcius in farenheit**

```
private double fToC(double f) {
        return ((f - 32) * 5 / 9);
}

private double cToF(double c) {
        return ((c * 9 / 5) + 32);
}
```

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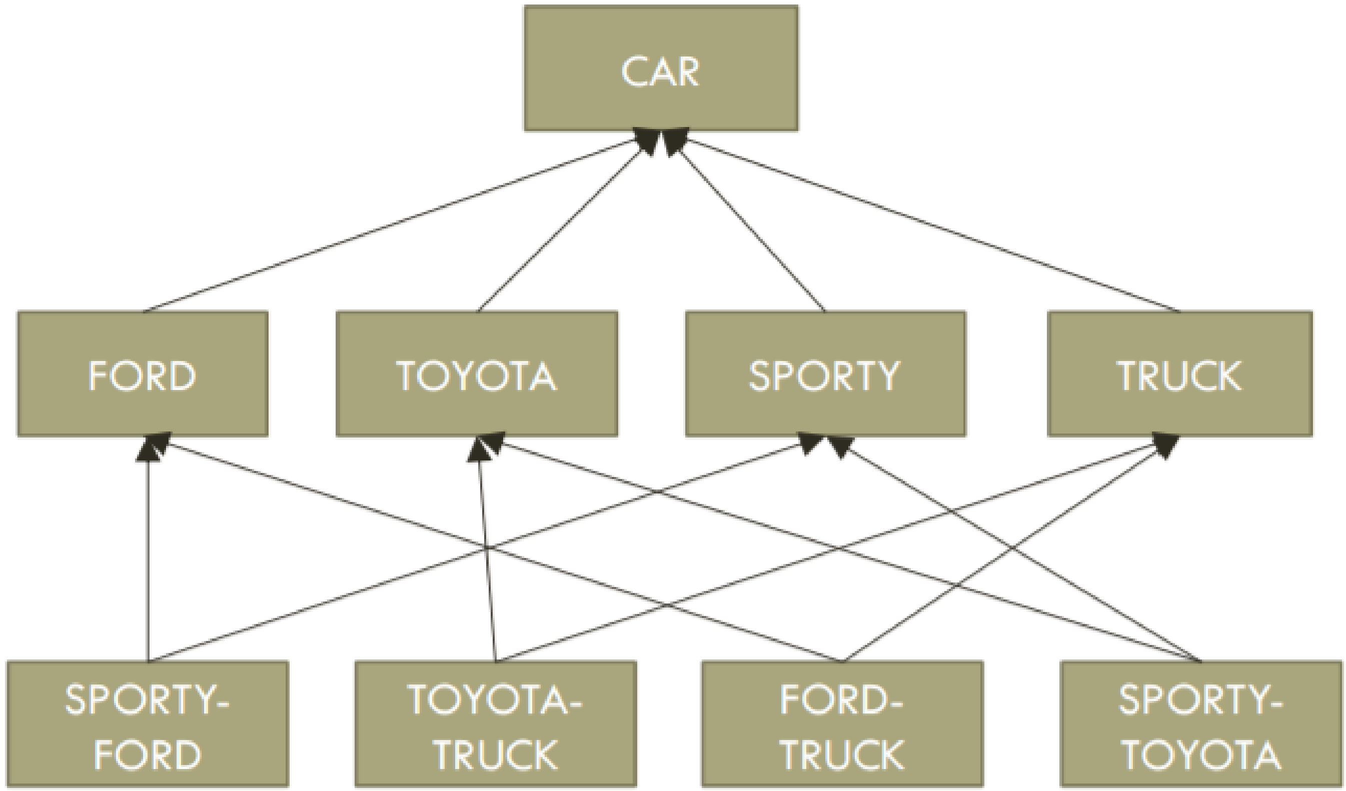
BRIDGE

- **Intent**
  - Separate a (logical) abstraction interface from its (physical) implementation(s)
  - Allows different implementations of an interface to be decided upon dynamically.

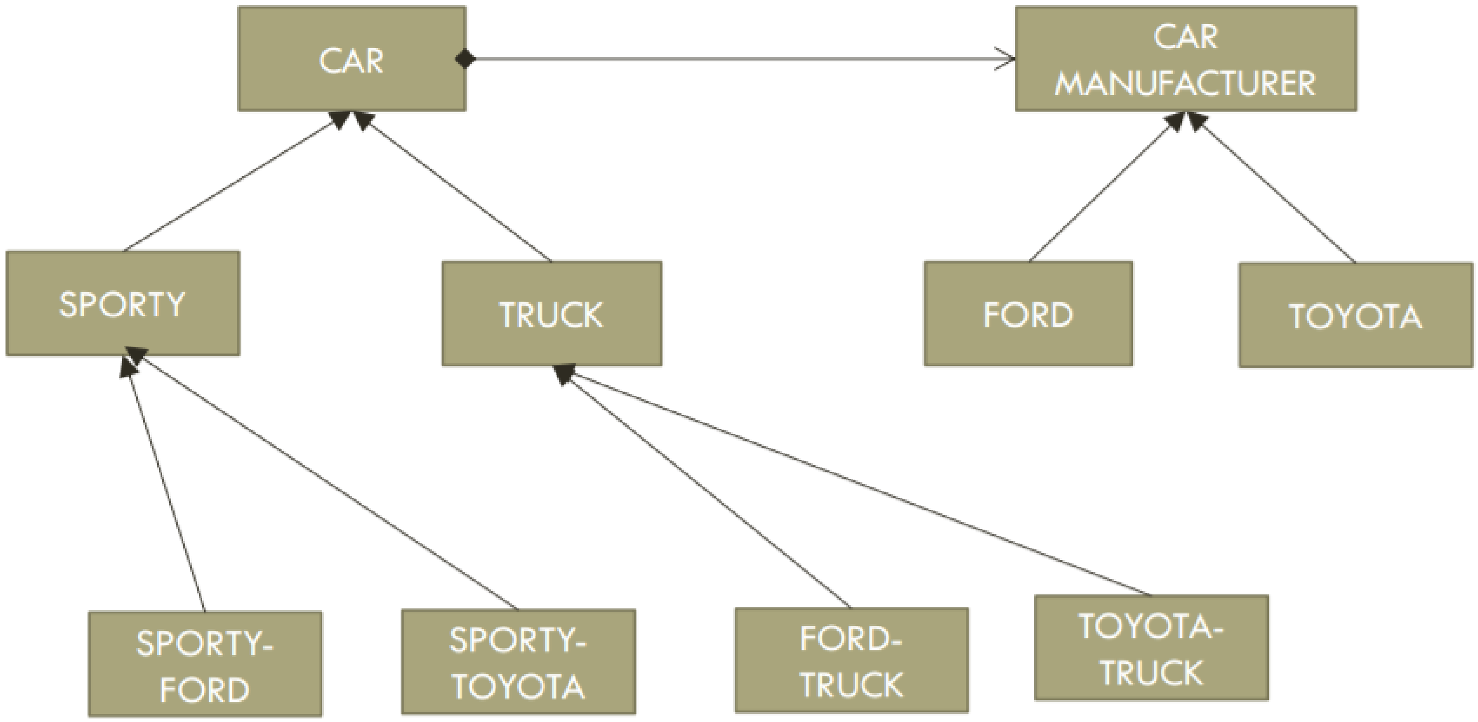
- **Applicability**
  - When interface & implementation should vary independently
  - Require a uniform interface to interchangeable class hierarchies

BRIDGE



Can this hierarchy be simplified and easy to understand? How?

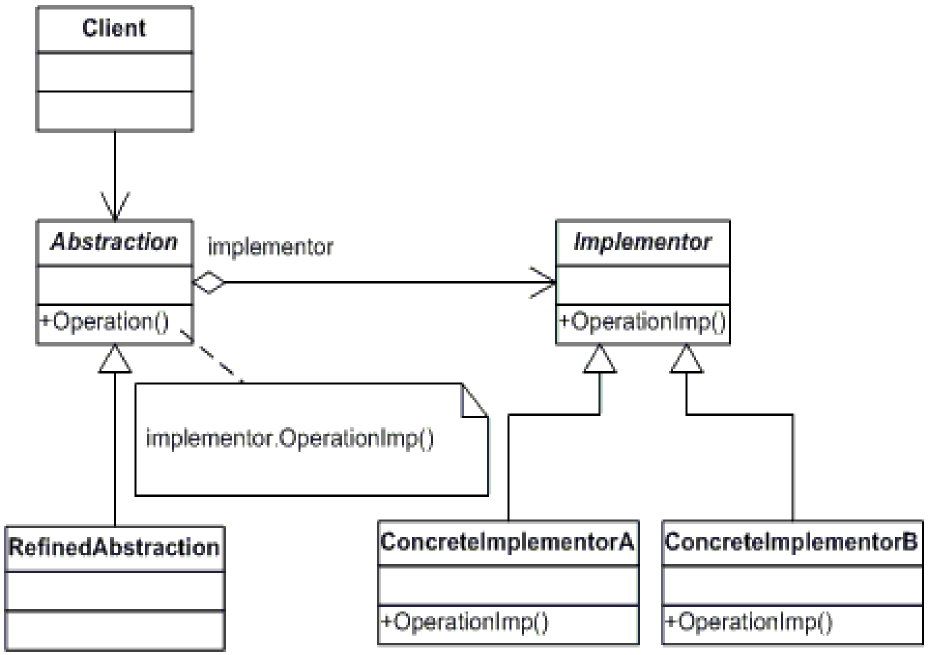
BRIDGE



CAR
CAR MANUFACTURER
SPORTY
TRUCK
FORD
TOYOTA
SPORTY-FORD
SPORTY-TOYOTA
FORD-TRUCK
TOYOTA-TRUCK

BRIDGE. STRUCTURE

- **Abstraction**
  - defines the abstraction's interface
  - maintains a reference to the Implementor
- **RefinedAbstraction**
  - extends abstraction interface
- **Implementor**
  - defines interface for implementations
- **ConcreteImplementor**
  - implements Implementor interface, ie defines an implementation



BRIDGE. EXAMPLE

- **Graphical User Interface Frameworks.**
  - Use the bridge pattern to separate abstractions from platform specific implementation.
  - GUI frameworks separate a Window abstraction from a Window implementation for Linux or Mac OS using the bridge pattern.

- **Object Persistence API.**
  - Many implementations depending on the presence or absence of a relational database, a file system, as well as on the underlying operating system

BRIDGE. EXAMPLE IMPLEMENTATION

```
public abstract class Car {
   private CarManufator manufactor;
    public Car ( CarManufator manufactor) {
        this.manufactor = manufactor
     }
}

public interface CarManufactor{
    public void getManufactor();
}
```

```
public class Ford implements
                                       CarManufactor{
     public void getManufactor(){
       System.out.print("Ford producer");
    }
}
public class Toyota implements
                                      CarManufactor{
    public void getManufactor(){
       System.out.print("Toyota producer");
    }
}
```

BRIDGE. EXAMPLE IMPLEMENTATION

```
public class Sporty extends Car {
   public Sporty(CarManufator manufactor) {
       super(manufactor);
System.out.println(manufactor.getManufactor()
                                        +“ for Sporty car”);
       }
}
public class Truck extends Car {
   public Truck(CarManufator manufactor) {
        super(manufactor);
System.out.println(manufactor.getManufactor()
                                        + “ for Truck car”);
 }
}
```

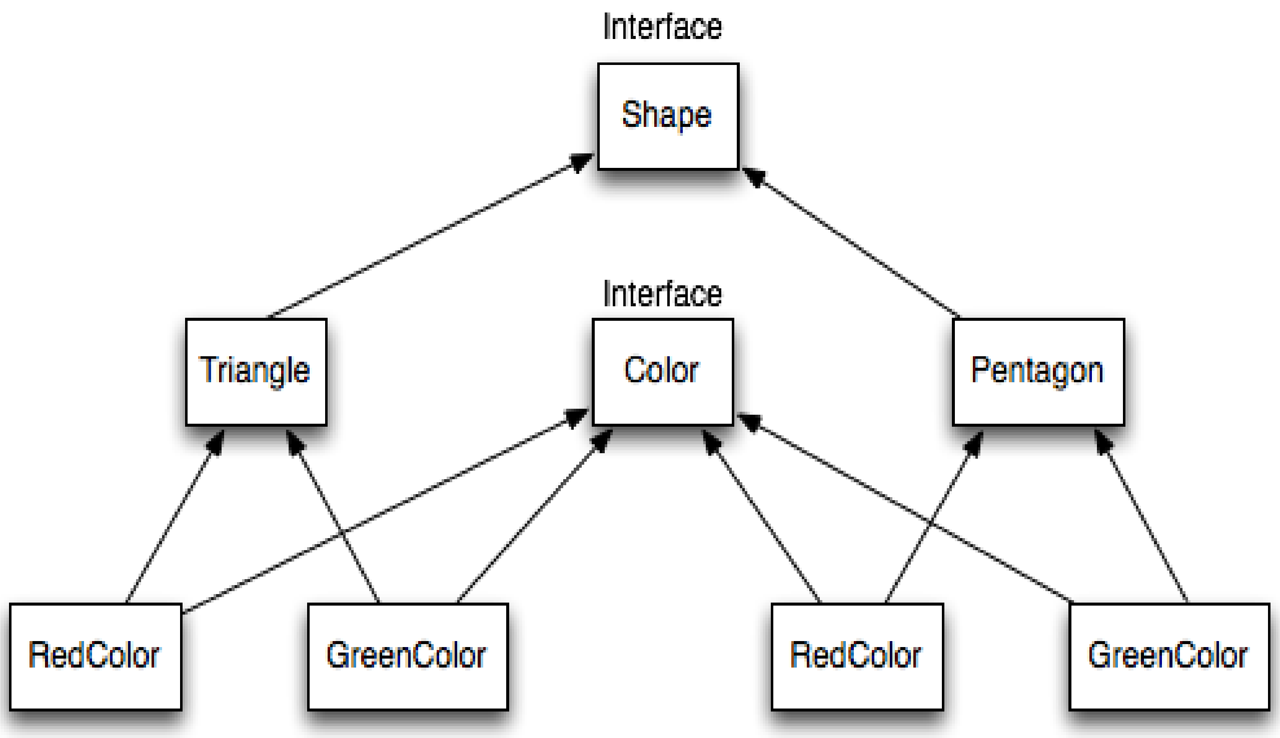
```
public class Client {
     public static void main( String
args[]){
         CarManufator mFord = new
Ford();
         CarManufator mToyota = new

Toyota();
         Car sportyFord = new

Sporty(mFord);
         Car sportyToyota = new

Sporty(mToyota);
         Car truckFord = new
Truck(mFord);
        Car truckToyota = new
```

BRIDGE



How you will refactor the following class hierarchy in order to follow bridge pattern?

BRIDGE

- **Decouples interface and implementation**
  - Decoupling Abstraction and Implementor also eliminates compile-time dependencies on implementation. Changing implementation class does not require recompile of abstraction classes.
- **Improves extensibility**
  - Both abstraction and implementations can be extended independently
- **Hides implementation details from clients**
- **More of a design-time pattern**

BRIDGE

- **Disadvantages**
  - abstractions that have only one implementation
  - creating the right Implementor
  - sharing implementors
  - use of multiple inheritance
- **Implementation Isues**
  - How, where, and when to decide which implementer to instantiate?
    - Depends:
      - If Abstraction knows about all concrete implementer, then it can instantiate in the constructor.
      - It can start with a default and change it later
      - Or it can delegate the decision to another object (to an abstract factory for example)
    - Can't implement a true bridge using multiple inheritance
  - A class can inherit publicly from an abstraction and privately from an implementation, but since it is static inheritance it bind an implementation permanently to its interface

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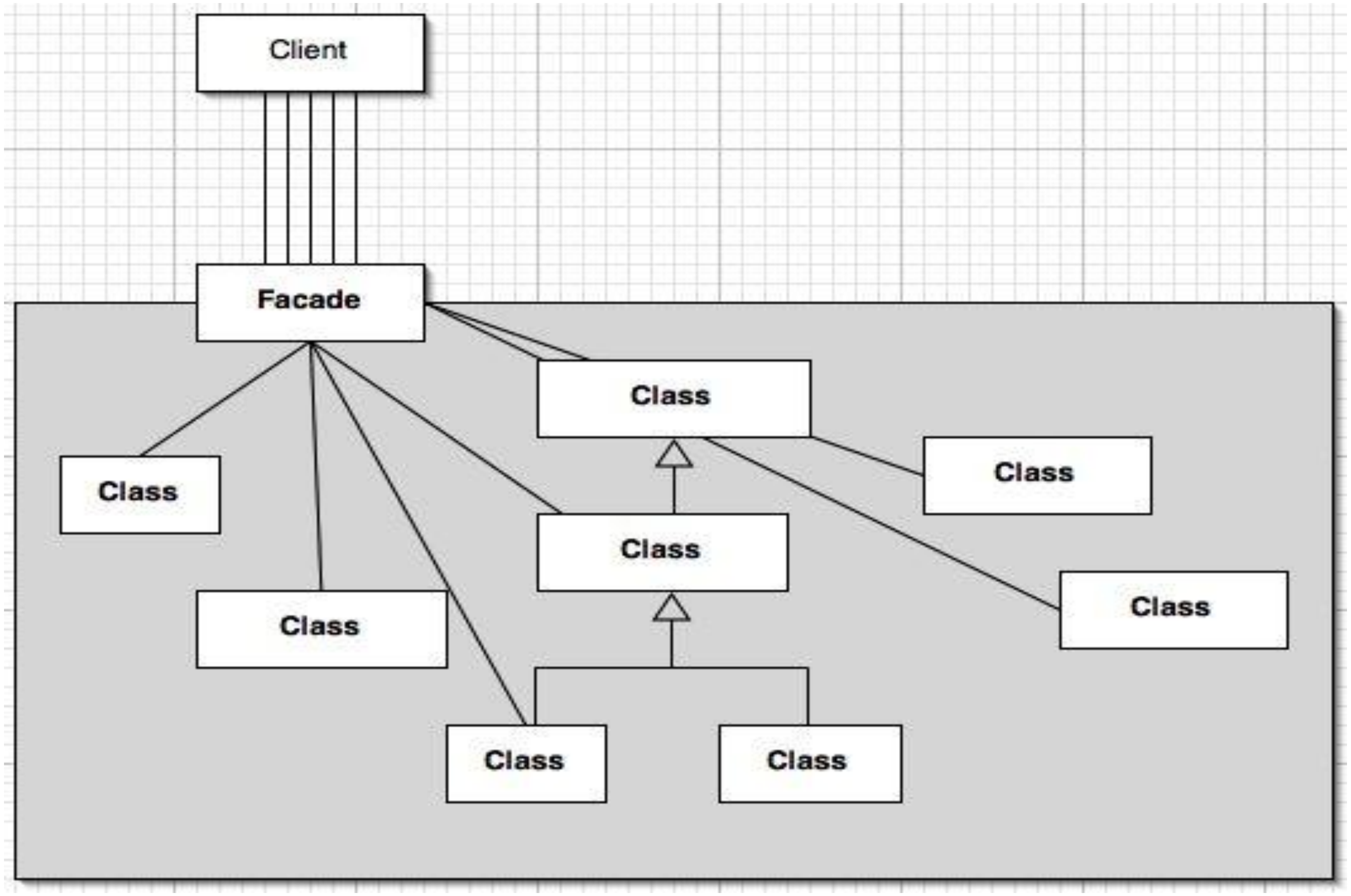
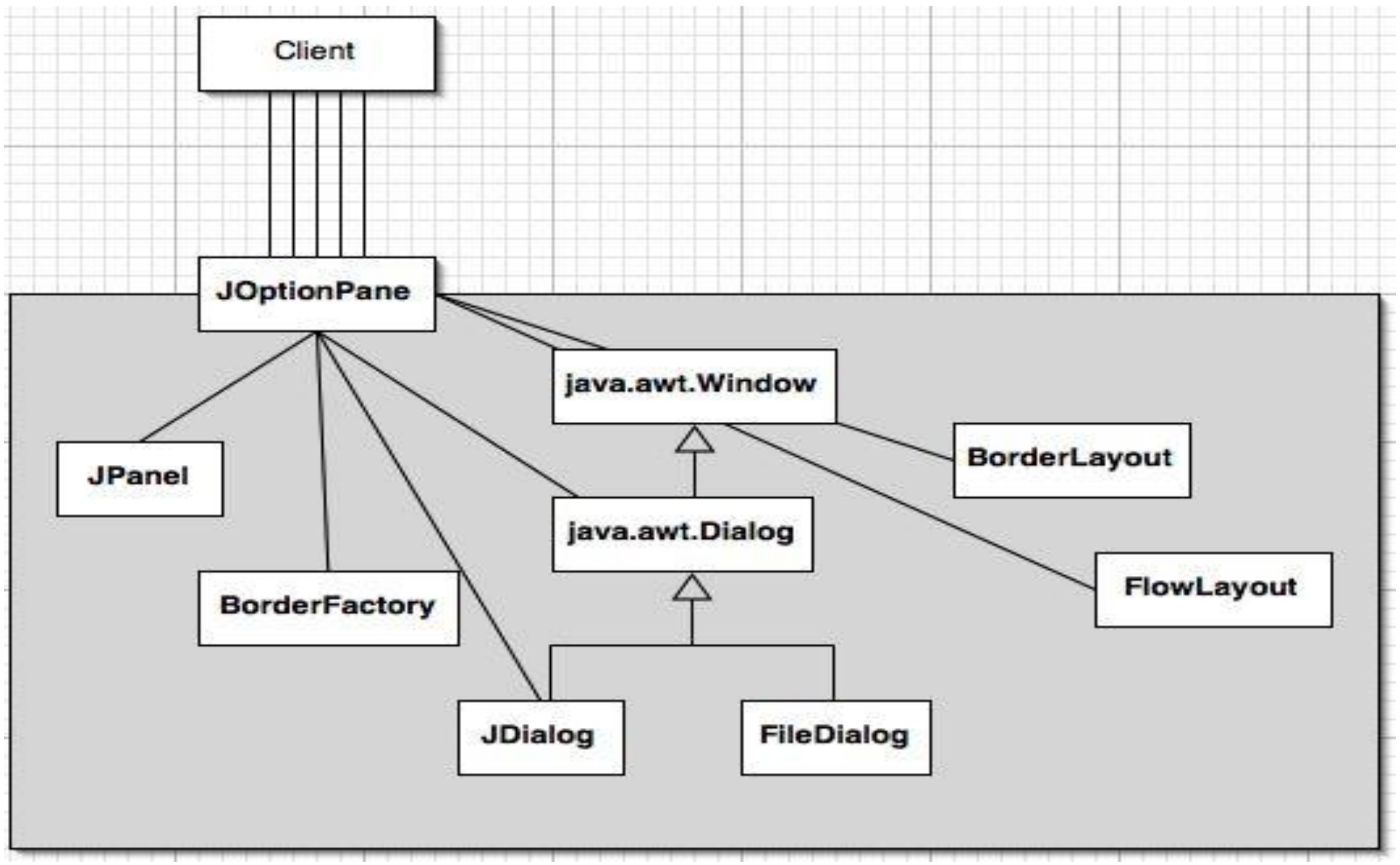
FACADE

- **Intent**
  - To provide a unified interface to a set of interfaces in a subsystem
  - To simplify an existing interface
  - Defines a higher-level interface that makes the subsystem easier to use
- **Problem**
  - Situation I: Wish to simplify a process for most clients
    - Subsystems are built for multiple applications
    - Most applications use only a small subset
    - Most applications interact in a predefined manner
  - Situation II: Wish to reduce the number of dependencies between client and implementation classes
    - Requires an interface that allows a level of isolation
  - Situation III: Wish to build a layered software design with all inter-layer communication between interfaces

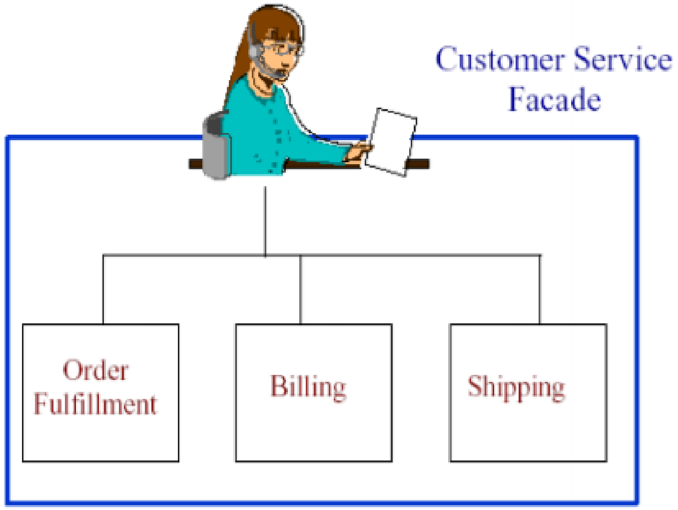
FACADE. STRUCTURE

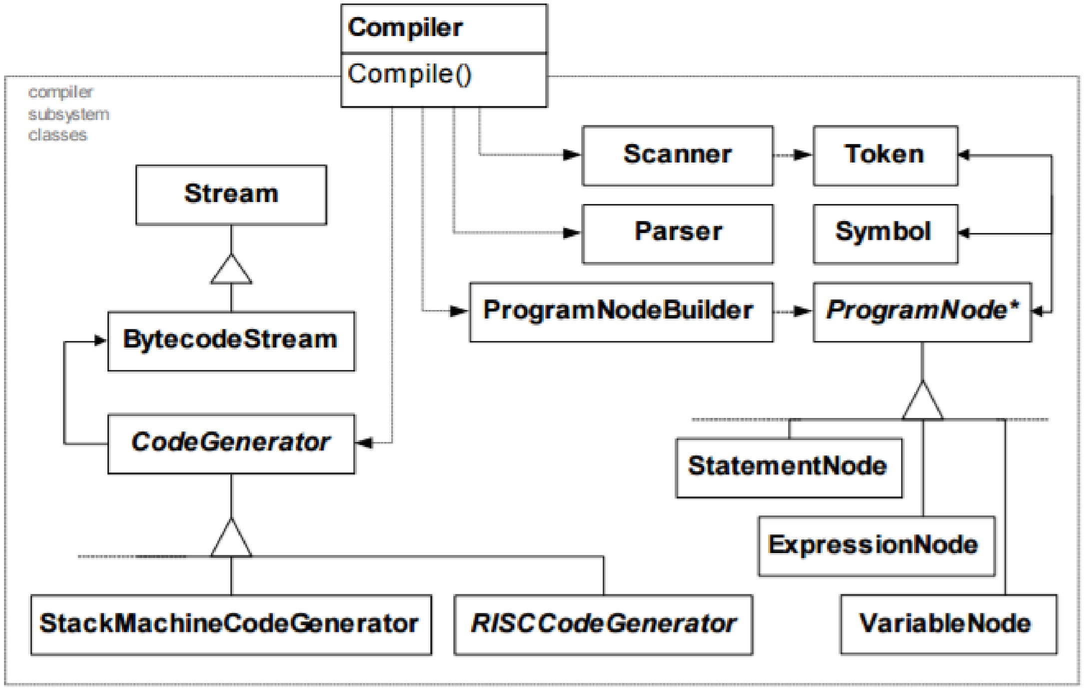


FACADE. EXAMPLE

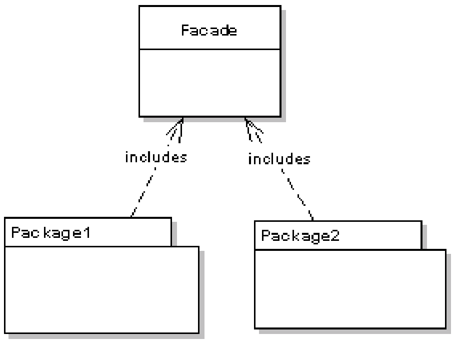


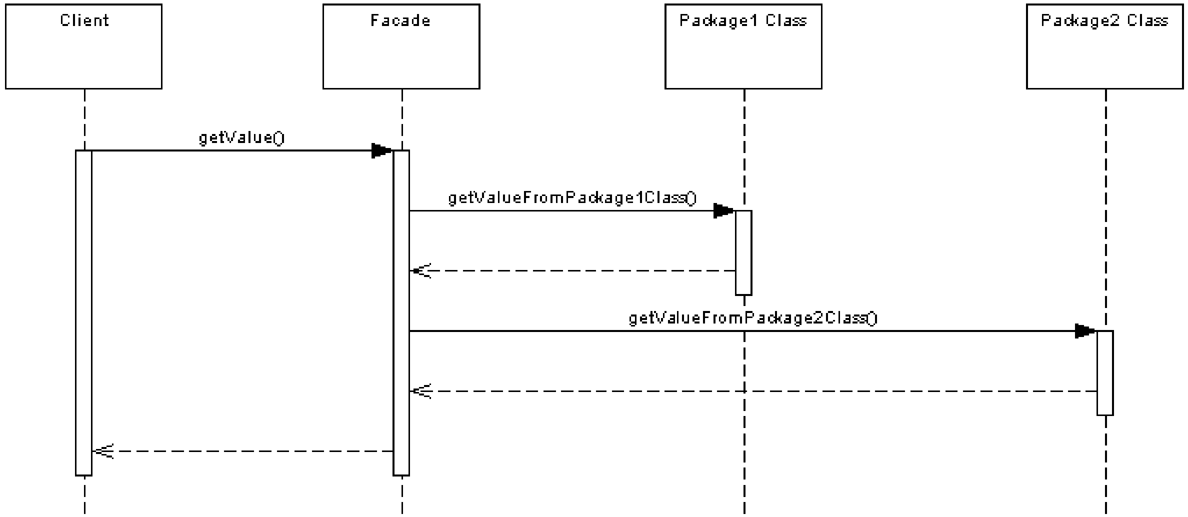
FACADE. EXAMPLE





FACADE. STRUCTURE





FACADE. EXAMPLE

- **Travel agent site that allows you to book hotels and flights**
  - we have 2 agents
    - HotelBooker
    - FlightBroker
  - HotelBooker

```
public class HotelBooker{
        public ArrayList<Hotel> getHotelNamesFor(Date from, Date to)
{
                //returns hotels available in the particular date range
}}
```

  - FlightBooker

```
public class FlightBooker{
        public ArrayList<Flight> getFlightsFor(Date from, Date to)   {
                //returns flights available in the particular date range
}}
```

FACADE. EXAMPLE

- **TravelFacade class allows the user to get their Hotel and Flight information in one call**

```
public class TravelFacade{
    private HotelBooker hotelBooker;
    private FlightBooker flightBooker;
    public void getFlightsAndHotels(Date from, Data to)  {
        ArrayList<Flight> flights = flightBooker.getFlightsFor(from, to);
        ArrayList<Hotel> hotels = hotelBooker.getHotelsFor(from, to);
        //process and return
}}
```

- **Client**

```
public class Client{
    public static void main(String[] args)   {
        TravelFacade facade = new TravelFacade();
        facade.getFlightsAndHotels(from, to);
}}
```

FACADE

- **Consequences**
  - Shields clients from subsystem complexity
  - Promotes weak coupling between clients and subsystems
    - Easier to swap out alternatives
  - Allows more advanced clients to by-pass and have direct subsystem access

FACADE

- **Implementation Issues**
  - Can involve nontrivial manipulation of subsystem
    - May require several steps in sequence or composition
    - May require temporary storage
  - Can completely hide subsystem
    - Place subsystem and façade in package
    - Make façade only public class
    - Can be difficult if subsystem objects returned to client
  - Can implement Façade as abstract class
    - Allows different concrete facades under same interface

STRUCTURAL PATTERNS

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FLYWEIGHT

- **Intent**
  - “Use Sharing to support large numbers of fine-grained objects efficiently.”
  - Simply put, a method for storing a small number of complex objects that are used repeatedly.
  - Flyweight factors the common properties of multiple instances of a class into a single object, saving space and maintenance of duplicate instances.
- **Problem**
  - Designing objects down to the lowest levels of system "granularity" provides optimal flexibility, but can be unacceptably expensive in terms of performance and memory usage.

FLYWEIGHT

- **Flyweighted strings**
  - Java Strings are flyweighted by the compiler wherever possible
- **Flyweighting works best on immutable objects**

```
public class StringTest {
    public static void main(String[] args) {
        String fly = "fly", weight = "weight";
        String fly2 = "fly", weight2 = "weight";

        System.out.println(fly == fly2);
         System.out.println(weight == weight2);

        String distinctString = fly + weight;
        System.out.println(distinctString == "flyweight");
        String flyweight = (fly + weight).intern();
         System.out.println(flyweight == "flyweight");
 }
}
```

FLYWEIGHT

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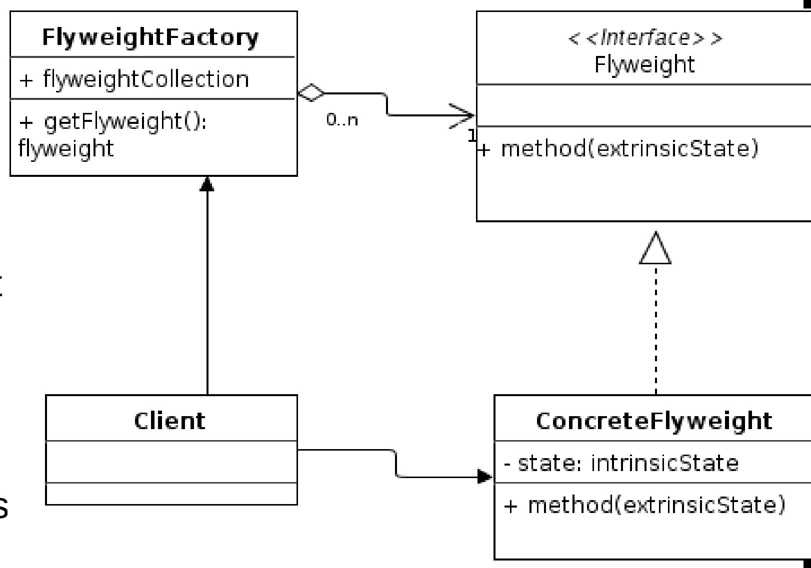
```
public class StringTest {
    public static void main(String[] args) {
        String fly = "fly", weight = "weight";
        String fly2 = "fly", weight2 = "weight";

        System.out.println(fly == fly2); //true
        System.out.println(weight == weight2); //true

        String distinctString = fly + weight;
        System.out.println(distinctString == "flyweight"); //false
        String flyweight = (fly + weight).intern();
        System.out.println(flyweight == "flyweight"); //true
    }
}
```

FLYWEIGH. APPLICABILITY

- Application has a large number of objects.
- Storage costs are high because of the large quantity of objects.
- Most object state can be made extrinsic.
- Many groups of objects may be replaced by relatively few once you remove their extrinsic state.
- The application doesn’t depend on object identity

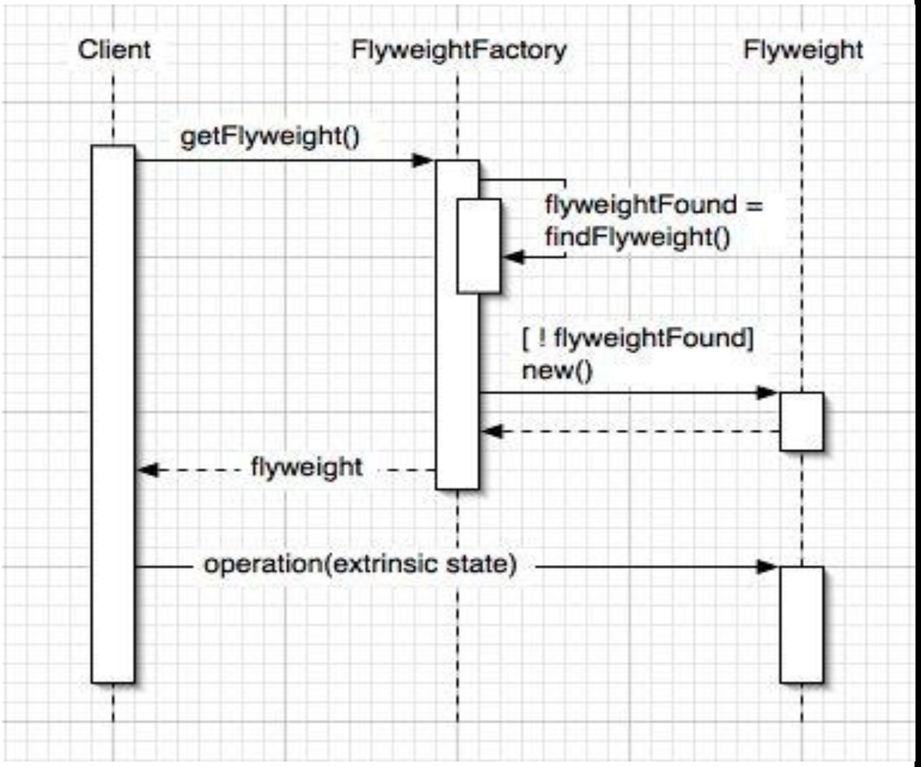
FLYWEIGHT. DESIGN

- **Flyweight**
  - Declares an interface through which flyweights can receive and act on extrinsic state.
- **ConcreteFlyweight**
  - Stores intrinsic state of the object.
  - Must be sharable.
  - Must maintain state that it is intrinsic to it, and must be able to manipulate state that is extrinsic.
- **FlyweightFactory**
  - The factory that creates and manages flyweight objects.
  - The factory ensures sharing of the flyweight objects
  - The factory maintains a pool of different flyweight objects and returns an object from the pool if it is already created, adds one to the pool and returns it in case it is new.
- **Client**
  - A client maintains references to flyweights in addition to computing and maintaining extrinsic state



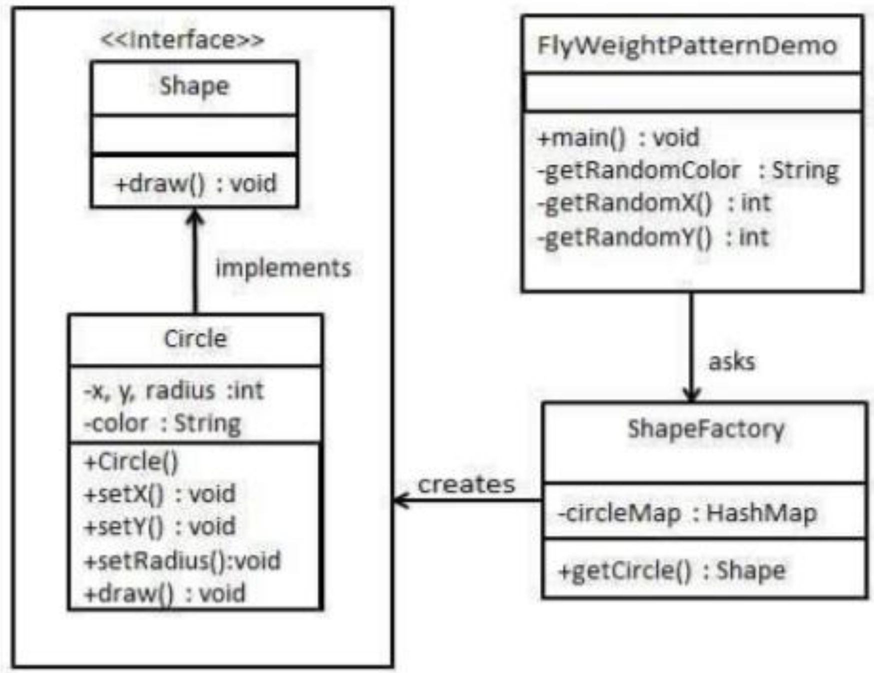
FLYWEIGHT

- Clients don't directly instantiate flyweights; instead they get them from a factory.
- The factory first checks to see if it has a flyweight that fits specific criteria (e.g., a blue or white line); if so, the factory returns a reference to the flyweight.
- If the factory can't locate a flyweight for the specified criteria, it instantiates one, adds it to the pool, and returns it to the client



FLYWEIGHT. EXAMPLE

- **Drawi 20 circles of different locations but using only 5 objects.**
  - Only 5 objects because we have only 5 colors to draw



FLYWEIGHT. EXAMPLE

```
public interface Shape {
   void draw();
}
public class Circle
         implements Shape {
   private String color;
    private int x;
    private int y;
    private int radius;
    public Circle(String color){
         this.color = color;
    }
```

```
public void setX(int x) {
   this.x = x;
 }
 public void setY(int y) {
    this.y = y;
}
public void setRadius(int radius) {
    this.radius = radius;
}
@Override
 public void draw() {
        System.out.println("Circle: Draw() [Color : "
          + color + ", x : " + x + ", y :" + y + ", radius :" + radius);
 }}
```

FLYWEIGHT. EXAMPLE

```
public class ShapeFactory {
    private static final HashMap<String, Shape> circleMap =
                                          new HashMap();
    public static Shape getCircle(String color) {
         Circle circle = (Circle)circleMap.get(color);
         if(circle == null) {
            circle = new Circle(color);
            circleMap.put(color, circle);
            System.out.println("Creating circle of color : "
                                   + color);
        }
        return circle;
    }
}

public class FlyweightPatternDemo {
 private static String getRandomColor() {
            return colors[(int)(Math.random()*colors.length)];
    }
private static final String colors[] = { "Red", "Green", "Blue",
                                      "White","Black" };
  public static void main(String[] args) {
   for(int i=0; i < 20; ++i) {
        Circle circle = (Circle) ShapeFactory.
                     getCircle(getRandomColor());
        circle.setX(getRandomX());
        circle.setY(getRandomY());
        circle.setRadius(100);
        circle.draw();
   }
 }
 private static int getRandomY() {
        return (int)(Math.random()*100);
  }
  private static int getRandomX() {
         return (int)(Math.random()*100 );
   }
}
```

FLYWEIGHT

- **Benefits**
  - If the size of the set of objects used repeatedly is substantially smaller than the number of times the object is logically used, there may be an opportunity for a considerable cost benefit
  - When To Use Flyweight:
    - There is a need for many objects to exist that share some intrinsic, unchanging information
    - Objects can be used in multiple contexts simultaneously
    - Acceptable that flyweight acts as an independent object in each instance

- **Consequences**
  - Overhead to track state
    - Transfer
    - Search
    - Computation
  - □When Not To Use Flyweight:
    - If the extrinsic properties have a large amount of state information that would need passed to the flyweight (overhead)
    - Need to be able to be distinguished shared from non-shared objects