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Strategy pattern

In computer programming, the **strategy pattern** (also known as the **policy pattern**) is a behavioral software design pattern that enables selecting an algorithm at runtime. Instead of implementing a single algorithm directly, code receives run-time instructions as to which in a family of algorithms to use.[1]

Strategy lets the algorithm vary independently from clients that use it.[2] Strategy is one of the patterns included in the influential book *Design Patterns* by Gamma et al.[3] that popularized the concept of using design patterns to describe how to design flexible and reusable object-oriented software. Deferring the decision about which algorithm to use until runtime allows the calling code to be more flexible and reusable.

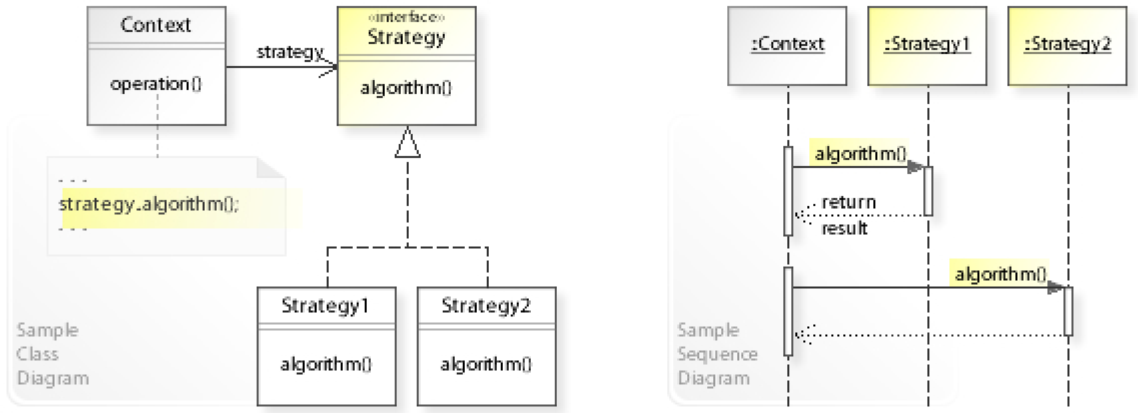
For instance, a class that performs validation on incoming data may use the strategy pattern to select a validation algorithm depending on the type of data, the source of the data, user choice, or other discriminating factors. These factors are not known until run-time and may require radically different validation to be performed. The validation algorithms (strategies), encapsulated separately from the validating object, may be used by other validating objects in different areas of the system (or even different systems) without code duplication.

Typically the strategy pattern stores a reference to some code in a data structure and retrieves it. This can be achieved by mechanisms such as the native function pointer, the first-class function, classes or class instances in object-oriented programming languages, or accessing the language implementation's internal storage of code via reflection.

Contents

Structure

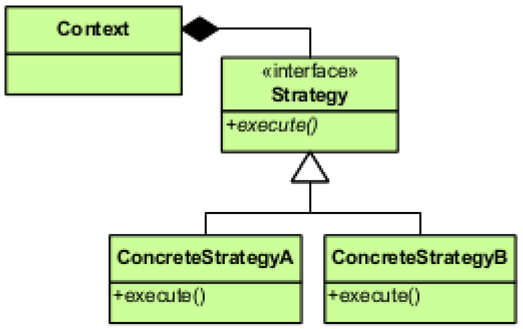
UML class and sequence diagram



A sample UML class and sequence diagram for the Strategy design pattern. [4]

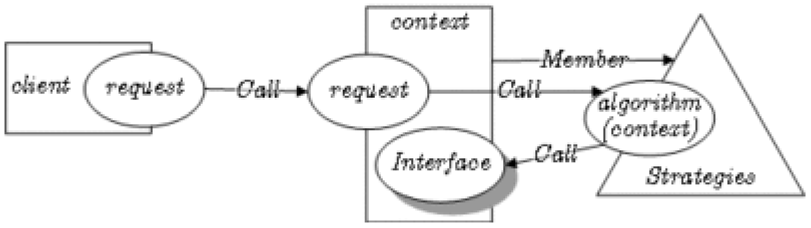
In the above UML class diagram, the `Context` class doesn't implement an algorithm directly. Instead, `Context` refers to the `Strategy` interface for performing an algorithm (`strategy.algorithm()`), which makes `Context` independent of how an algorithm is implemented. The `Strategy1` and `Strategy2` classes implement the `Strategy` interface, that is, implement (encapsulate) an algorithm.
The UML sequence diagram shows the run-time interactions: The `Context` object delegates an algorithm to different `Strategy` objects. First, `Context` calls `algorithm()` on a `Strategy1` object, which performs the algorithm and returns the result to `Context`. Thereafter, `Context` changes its strategy and calls `algorithm()` on a `Strategy2` object, which performs the algorithm and returns the result to `Context`.

Class diagram



Strategy Pattern in UML

[5]



Strategy pattern in LePUS3 (legend (http://lepus.org.uk/ref/legend/legend.xml))

Example

C#

The following example is in C#.

```
public class StrategyPatternWiki
{
    public static void Main(String[] args)
    {
        // Prepare strategies
        IBillingStrategy normalStrategy    = new NormalStrategy();
        IBillingStrategy happyHourStrategy = new HappyHourStrategy();

        Customer firstCustomer = new Customer(normalStrategy);

        // Normal billing
        firstCustomer.Add(1.0, 1);

        // Start Happy Hour
        firstCustomer.Strategy = happyHourStrategy;
        firstCustomer.Add(1.0, 2);

        // New Customer
        Customer secondCustomer = new Customer(happyHourStrategy);
        secondCustomer.Add(0.8, 1);
        // The Customer pays
        firstCustomer.PrintBill();

        // End Happy Hour
        secondCustomer.Strategy = normalStrategy;
        secondCustomer.Add(1.3, 2);
        secondCustomer.Add(2.5, 1);
        secondCustomer.PrintBill();
    }
}


class Customer
{
    private IList<double> drinks;

    // Get/Set Strategy
    public IBillingStrategy Strategy { get; set; }

    public Customer(IBillingStrategy strategy)
    {
        this.drinks = new List<double>();
        this.Strategy = strategy;
    }

    public void Add(double price, int quantity)
    {
        this.drinks.Add(this.Strategy.GetActPrice(price * quantity));
    }

    // Payment of bill
    public void PrintBill()
    {
        double sum = 0;
        foreach (double i in this.drinks)
        {
            sum += i;
        }
        Console.WriteLine("Total due: " + sum);
        this.drinks.Clear();
    }
}

interface IBillingStrategy
{
    double GetActPrice(double rawPrice);
}

// Normal billing strategy (unchanged price)
class NormalStrategy : IBillingStrategy
```

```
{
    public double GetActPrice(double rawPrice)
    {
        return rawPrice;
    }
}

// Strategy for Happy hour (50% discount)
class HappyHourStrategy : IBillingStrategy
{
    public double GetActPrice(double rawPrice)
    {
        return rawPrice * 0.5;
    }
}
```

Java

The following example is in Java.

```
import java.util.ArrayList;

@FunctionalInterface
interface BillingStrategy {
    // use a price in cents to avoid floating point round-off error
    int getActPrice(int rawPrice);

    //Normal billing strategy (unchanged price)
    static BillingStrategy normalStrategy() {
        return rawPrice -> rawPrice;
    }

    //Strategy for Happy hour (50% discount)
    static BillingStrategy happyHourStrategy() {
        return rawPrice -> rawPrice / 2;
    }
}

class Customer {
    private final ArrayList<Integer> drinks = new ArrayList<>();
    private BillingStrategy strategy;

    public Customer(BillingStrategy strategy) {
        this.strategy = strategy;
    }

    public void add(int price, int quantity) {
        this.drinks.add(this.strategy.getActPrice(price*quantity));
    }

    // Payment of bill
    public void printBill() {
        int sum = this.drinks.stream().mapToInt(v -> v).sum();
        System.out.println("Total due: " + sum / 100.0);
        this.drinks.clear();
    }

    // Set Strategy
    public void setStrategy(BillingStrategy strategy) {
        this.strategy = strategy;
    }
}

public class StrategyPattern {
    public static void main(String[] arguments) {
        // Prepare strategies
        BillingStrategy normalStrategy    = BillingStrategy.normalStrategy();
        BillingStrategy happyHourStrategy = BillingStrategy.happyHourStrategy();

        Customer firstCustomer = new Customer(normalStrategy);

        // Normal billing
        firstCustomer.add(100, 1);

        // Start Happy Hour
        firstCustomer.setStrategy(happyHourStrategy);
        firstCustomer.add(100, 2);

        // New Customer
        Customer secondCustomer = new Customer(happyHourStrategy);
        secondCustomer.add(80, 1);
        // The Customer pays
        firstCustomer.printBill();

        // End Happy Hour
        secondCustomer.setStrategy(normalStrategy);
        secondCustomer.add(130, 2);
        secondCustomer.add(250, 1);
        secondCustomer.printBill();
    }
}
```

Strategy and open/closed principle

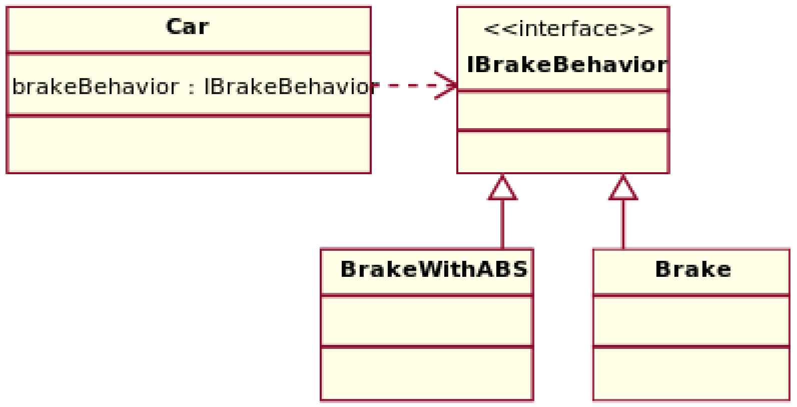
According to the strategy pattern, the behaviors of a class should not be inherited. Instead they should be encapsulated using interfaces. This is compatible with the open/closed principle (OCP), which proposes that classes should be open for extension but closed for modification.

As an example, consider a car class. Two possible functionalities for car are *brake* and *accelerate*. Since accelerate and brake behaviors change frequently between models, a common approach is to implement these behaviors in subclasses. This approach has significant drawbacks: accelerate and brake behaviors must be declared in each new Car model. The work of managing these behaviors increases greatly as the number of models increases, and requires code to be duplicated across models. Additionally, it is not easy to determine the exact nature of the behavior for each model without investigating the code in each.

The strategy pattern uses composition instead of inheritance. In the strategy pattern, behaviors are defined as separate interfaces and specific classes that implement these interfaces. This allows better decoupling between the behavior and the class that uses the behavior. The behavior can be changed without breaking the classes that use it, and the classes can switch between behaviors by changing the specific implementation used without requiring any significant code changes. Behaviors can also be changed at run-time as well as at design-time. For instance, a car object's brake behavior can be changed from `BrakeWithABS()` to `Brake()` by changing the `brakeBehavior` member to:

```java
brakeBehavior = new Brake();
```

```java
/* Encapsulated family of Algorithms
 * Interface and its implementations
 */
public interface IBrakeBehavior {
    public void brake();
}

public class BrakeWithABS implements IBrakeBehavior {
    public void brake() {
        System.out.println("Brake with ABS applied");
    }
}

public class Brake implements IBrakeBehavior {
    public void brake() {
        System.out.println("Simple Brake applied");
    }
}

/* Client that can use the algorithms above interchangeably */
public abstract class Car {
    private IBrakeBehavior brakeBehavior;

    public Car(IBrakeBehavior brakeBehavior) {
      this.brakeBehavior = brakeBehavior;
    }

    public void applyBrake() {
        brakeBehavior.brake();
    }

    public void setBrakeBehavior(IBrakeBehavior brakeType) {
        this.brakeBehavior = brakeType;
    }
}

/* Client 1 uses one algorithm (Brake) in the constructor */
public class Sedan extends Car {
```



Accelerate and brake behaviors must be declared in each new car model.

```
    public Sedan() {
        super(new Brake());
    }
}

/* Client 2 uses another algorithm (BrakeWithABS) in the constructor */
public class SUV extends Car {
    public SUV() {
        super(new BrakeWithABS());
    }
}

/* Using the Car example */
public class CarExample {
    public static void main(final String[] arguments) {
        Car sedanCar = new Sedan();
        sedanCar.applyBrake();  // This will invoke class "Brake"

        Car suvCar = new SUV();
        suvCar.applyBrake();    // This will invoke class "BrakeWithABS"

        // set brake behavior dynamically
        suvCar.setBrakeBehavior( new Brake() );
        suvCar.applyBrake();    // This will invoke class "Brake"
    }
}
```

See also

- Dependency injection
- Higher-order function
- List of object-oriented programming terms
- Mixin
- Policy-based design
- Type class
- Entity–component–system
- Composition over inheritance

References

1. "The Strategy design pattern - Problem, Solution, and Applicability" (http://w3sdesign.com/?gr=b09&ugr=proble). *w3sDesign.com*. Retrieved 2017-08-12.
2. Eric Freeman, Elisabeth Freeman, Kathy Sierra and Bert Bates, *Head First Design Patterns*, First Edition, Chapter 1, Page 24, O'Reilly Media, Inc, 2004. ISBN 978-0-596-00712-6
3. Erich Gamma, Richard Helm, Ralph Johnson, John Vlissides (1994). *Design Patterns: Elements of Reusable Object-Oriented Software*. Addison Wesley. pp. 315ff. ISBN 0-201-63361-2.

4. "The Strategy design pattern - Structure and Collaboration" (http://w3sdesign.com/?gr=b09&ugr=struct). *w3sDesign.com*. Retrieved 2017-08-12.
5. http://www.mcdonaldland.info/2007/11/28/40/

External links

- Strategy Pattern in UML (Spanish, but english model) (http://design-patterns-with-uml.blogspot.com.ar/2013/02/strategy-pattern.html)
- Strategy Pattern for Java article (http://www.javaworld.com/javaworld/jw-04-2002/jw-0426-designpatterns.html)
- Strategy Pattern for C article (http://www.adamtornhill.com/Patterns%20in%20C%203,%20STRATEGY.pdf)
- Strategy pattern in UML and in LePUS3 (http://www.lepus.org.uk/ref/companion/Strategy.xml) (a formal modelling notation)
- Refactoring: Replace Type Code with State/Strategy (http://martinfowler.com/refactoring/catalog/replaceTypeCodeWithStateStrategy.html)
- Implementation of the Strategy pattern in JavaScript (http://www.aleccove.com/2016/02/the-strategy-pattern-in-javascript)

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