Strategy Design Pattern

Design patterns are formalized best practices that programmers can use to ***solve common problems*** when ***designing*** an ***application*** or ***system***. They are ***not*** directly ***executable code*** but rather ***descriptions*** of ***how to solve a problem***, which can be implemented in various ways depending on the specific context.

Let's begins with an **example** where we are developing an **application** to simulate **various types** of **robots**.

- We start by designing an **abstract class** named **Robot**, which **implements** the **common functionalities** such as **walk()** and **talk()**, and **declares** an **abstract method projection()**. Each specific robot type will provide its **own** implementation of the **projection method**.

- Initially, we have two types of robots: ***CompanionRobot*** and ***WorkerRobot***. Both robots **share** the ability to **talk** and **walk**, so the current design works well.

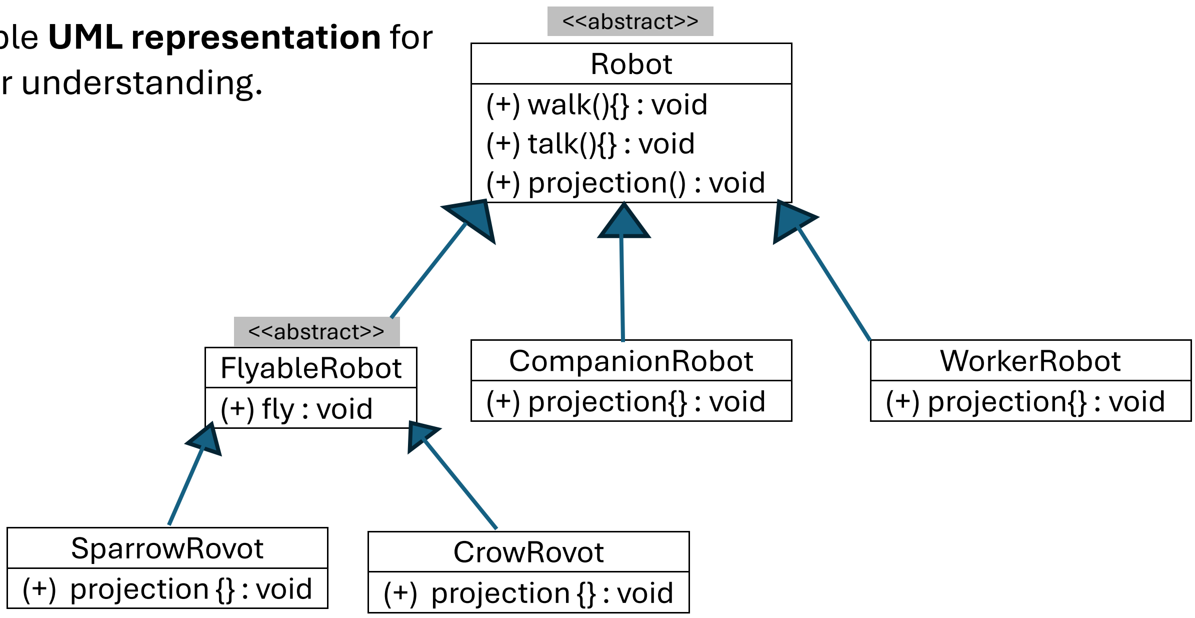
- However, imagine a new robot called ***SparrowRobot*** is introduced, which has the ability to ***fly***. Following that, more **flyable robots** like ***CrowRobot*** are developed. At this point, we face a **design decision**:
  - Should we **add** a ***fly()*** method to the **base Robot class**?
  - Or should we **create a new interface** like ***FlyableRobot*** that **extends Robot**?

- Now, suppose another robot is invented that **flies** using ***jets*** instead of ***wings***. This means we now have **two categories** of **flying behavior**: ***fly by wings*** and ***fly by jet***. To support this, we would either need to **rewrite** significant portions of the code or restructure the class hierarchy altogether.

- A similar **issue** arises with **walking behavior**. Some robots may **walk using legs**, while others might **move using wheels**. If we use **interfaces** alone to represent these behaviors, we risk **violating** the ***Open/Closed Principle (OCP)*** — our classes are **not closed** for **modification** and **require frequent changes** as **new behaviors emerge**.

- This scenario clearly illustrates the need for a **more flexible** and **extensible design** — **one** that can **handle evolving behaviors** without **constantly altering existing code**.

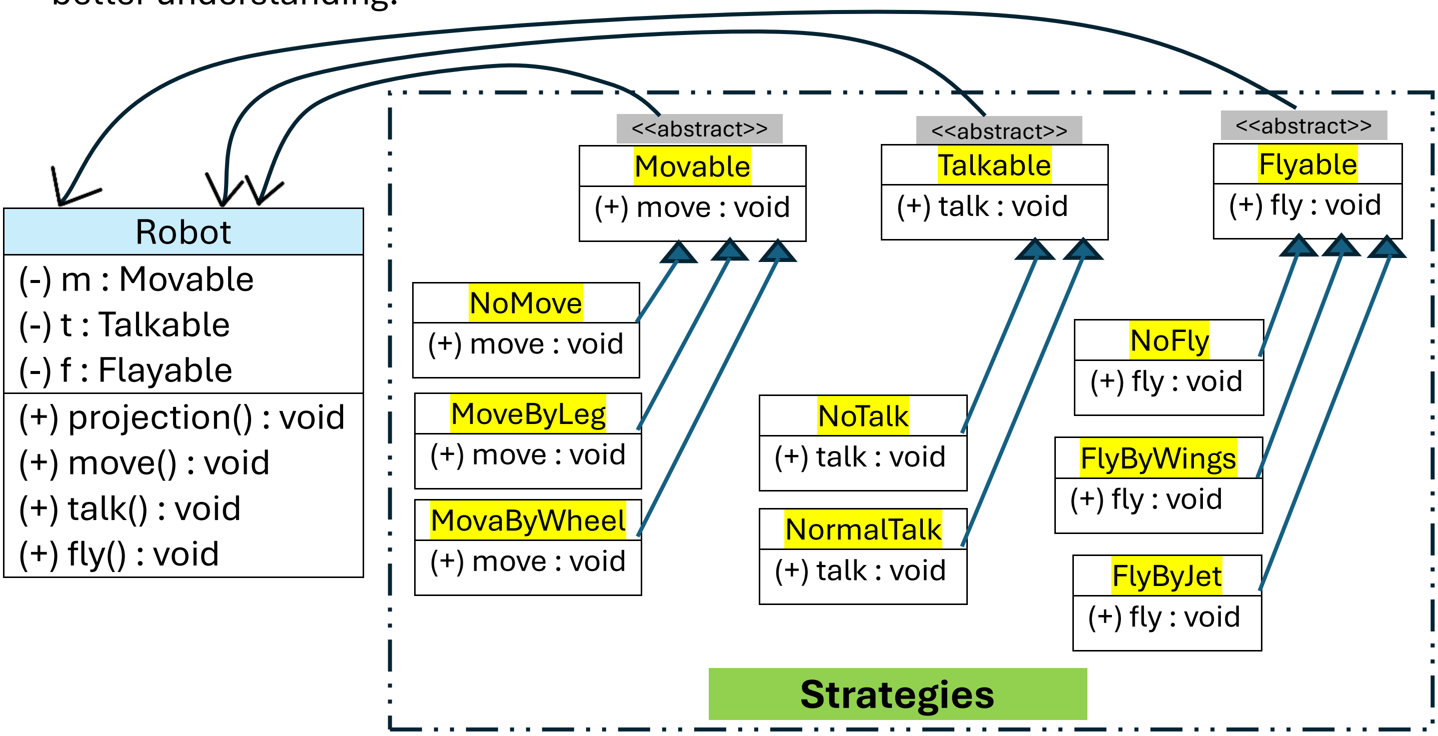
- Sample **UML representation** for better understanding.



Problems with inheritance:

- Code reusability ❌.
- To add new feature **a lot of** changes were required ✅.
- **open-close principle** (OCP) ❌.

- To address these issues, I will use the ***Strategy Design Pattern***, which states: **“Define a <u>family</u> of <u>algorithms</u> (or <u>strategies</u>), <u>encapsulate</u> each one, and make them <u>interchangeable</u> so that they can <u>vary</u> <u>independently</u> at <u>runtime</u>.”**
- I will create <u>three</u> separate interfaces — **Movable**, **Talkable**, and **Flyable** — and use them as ***composed objects*** within the Robot class.
- By doing so, we can ***dynamically*** <u>assign</u> or <u>change</u> behaviours related to <u>movement</u>, <u>communication</u>, and <u>flying</u> without <u>modifying</u> the <u>existing</u> robot <u>code</u>.
- Sample **UML representation** for better understanding.



- By **using constructor injection**, we can now dynamically assign any valid combination of behaviours at runtime without modifying existing code.
- This approach fully follows the **Open-Closed Principle (OCP)** — the system is **open for extension but closed for modification**.

💡 **Benefits**

- **code reusability** and **flexibility**. ✅
- **Open/Closed Principle** (OCP). ✅
- Bulky **inheritance tree** logic. ❌
- Makes behaviour **interchangeable** at **runtime**. ✅

@Sibasundarj8

Robot

```java
public abstract class Robot {
    private final Movable m;
    private final Talkable t;
    private final Flyable f;
    // constructor injection
    public Robot (Movable m, Talkable t, Flyable f) {
        this.m = m;
        this.t = t;
        this.f = f;
    }
    public void move() { m.move(); }
    public void talk() { t.talk(); }
    public void fly() { f.fly(); }
    public abstract void projection();
}
```

Talkable interface & Talking strategies

```java
public interface Talkable {
    void talk();
}
public class NoTalk implements Talkable {
    @Override
    public void talk() {
        System.out.println("Can't Talk");
    }
}
public class NormalTalk implements Talkable {
    @Override
    public void talk() {
        System.out.println("Talks Normally");
    }
}
```

Worker Robot

```java
public class WorkerRobot extends Robot {
    public WorkerRobot(Movable m, Talkable t, Flyable f) {
        super(m, t, f);
    }
    @Override
    public void projection() {
        System.out.println("""
            Worker robot : Power | 100%
                           Brain  | 20%
            """);
    }
}
```

Movable interface & Moving strategies

```java
public interface Movable {
    void move();
}
public class NoMove implements Movable {
    @Override
    public void move() {
        System.out.println("Can't Move");
    }
}
public class MoveByLeg implements Movable {
    @Override
    public void move() {
        System.out.println("Move using Legs");
    }
}
public class MoveByWheel implements Movable {
    @Override
    public void move() {
        System.out.println("Move using Wheels");
    }
}
```

CompanionRobot

```java
public class CompanionRobot extends Robot {
    public CompanionRobot(Movable m, Talkable t, Flyable f) {
        super(m, t, f);
    }
    @Override
    public void projection() {
        System.out.println("""
            Companion robot : Power | 30%
                              Brain  | 100%
            """);
    }
}
```

Flyable interface & Flying strategies

```java
public interface Flyable {
    void fly();
}
public class NoFly implements Flyable {
    @Override
    public void fly() {
        System.out.println("Can't Fly");
    }
}
public class FlyByWings implements Flyable {
    @Override
    public void fly() {
        System.out.println("Fly using Wings");
    }
}
public class FlyByJet implements Flyable {
    @Override
    public void fly() {
        System.out.println("Fly using Jet");
    }
}
```

ParrotRobot

```java
public class ParrotRobot extends Robot {
    public ParrotRobot(Movable m, Talkable t, Flyable f) {
        super(m, t, f);
    }
    @Override
    public void projection() {
        System.out.println("""
            Parrot robot : Power | 30%
                           Brain  | 10%
                           Speed | 40 km/h
                           Color  | Green
            """);
    }
}
```

Clint Code

```java
public class Client {
    public static void main(String[] args) {
        Robot companion = new CompanionRobot(
                new MoveByLeg(),        // moving strategy
                new NormalTalk(),       // talking strategy
                new NoFly());           // flying strategy
        Robot worker = new WorkerRobot(
                new MoveByWheel(),      // moving strategy
                new NoTalk(),           // talking strategy
                new NoFly());           // flying strategy
        Robot parrot = new ParrotRobot(
                new MoveByLeg(),        // moving strategy
                new NormalTalk(),       // talking strategy
                new FlyByWings());      // flying strategy
        Robot crow = new CrowRobot(
                new MoveByLeg(),        // moving strategy
                new NoTalk(),           // talking strategy
                new FlyByWings());      // flying strategy

        companion.projection();
        worker.projection();
        parrot.projection();
        crow.projection();

        companion.move();
        worker.move();
        parrot.talk();
        crow.fly();
    }
}
```

CrowRobot

```java
public class CrowRobot extends Robot {
    public CrowRobot(Movable m, Talkable t, Flyable f) {
        super(m, t, f);
    }
    @Override
    public void projection() {
        System.out.println("""
                Crow robot : Power | 40%
                             Brain   | 20%
                             Speed | 45 km/h
                             Color   | Black
                """);
    }
}
```

----------Output of Client Code----------

```
Companion robot : Power | 30%
          Brain | 100%

Worker robot : Power | 100%
          Brain | 20%

Parrot robot : Power | 30%
          Brain | 10%
          Speed | 40 km/h
          Color | Green

Crow robot : Power | 40%
          Brain | 20%
          Speed | 45 km/h
          Color | Black

Move using Legs
Move using Wheels
Talks Normally
Fly using Wings
```

```
src
  RobotSimulation
    Strategies
      Flyable
      FlyByJet
      FlyByWings
      Movable
      MoveByLeg
      MoveByWheel
      NoFly
      NoMove
      NormalTalk
      NoTalk
      Talkable
    CompanionRobot
    CrowRobot
    ParrotRobot
    Robot
    WorkerRobot
  Client
.gitignore
RobotSimulation.iml
```

Conclusion:

- Encapsulate what varies & keep it separate from what remains same.
- Solution to inheritance is not more inheritance.
- Composition should be favoured over inheritance.
- Don't repeat yourself (DRY).

@Sibasundarj8