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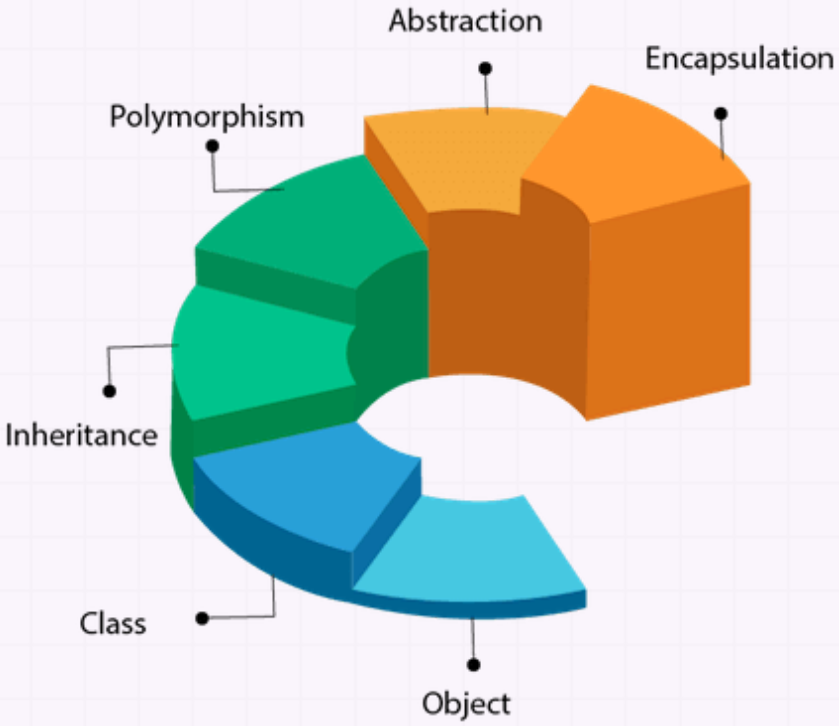
OOPs Concepts with Real-Life Examples in Java



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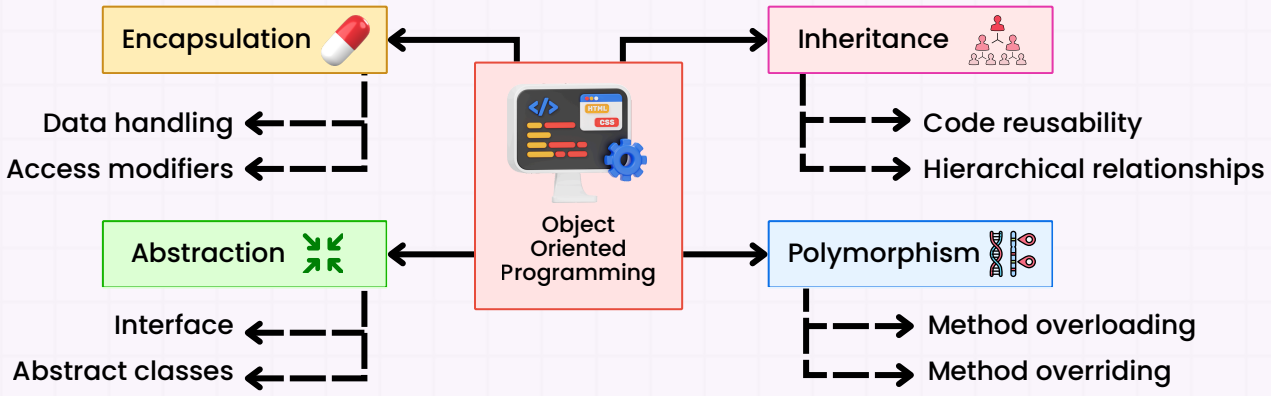
Introduction

Object-oriented programming (OOP) is a powerful paradigm used in Java to structure code in a way that models real-world entities.

This guide will explore the four key principles of OOP:

1. Encapsulation
2. Inheritance
3. Polymorphism
4. Abstraction



We'll also cover Constructors and Overloading.

For each concept, we'll provide:

- A clear explanation
- Detailed real-life examples
- Practical Java code examples

Let's dive in!

1. Encapsulation

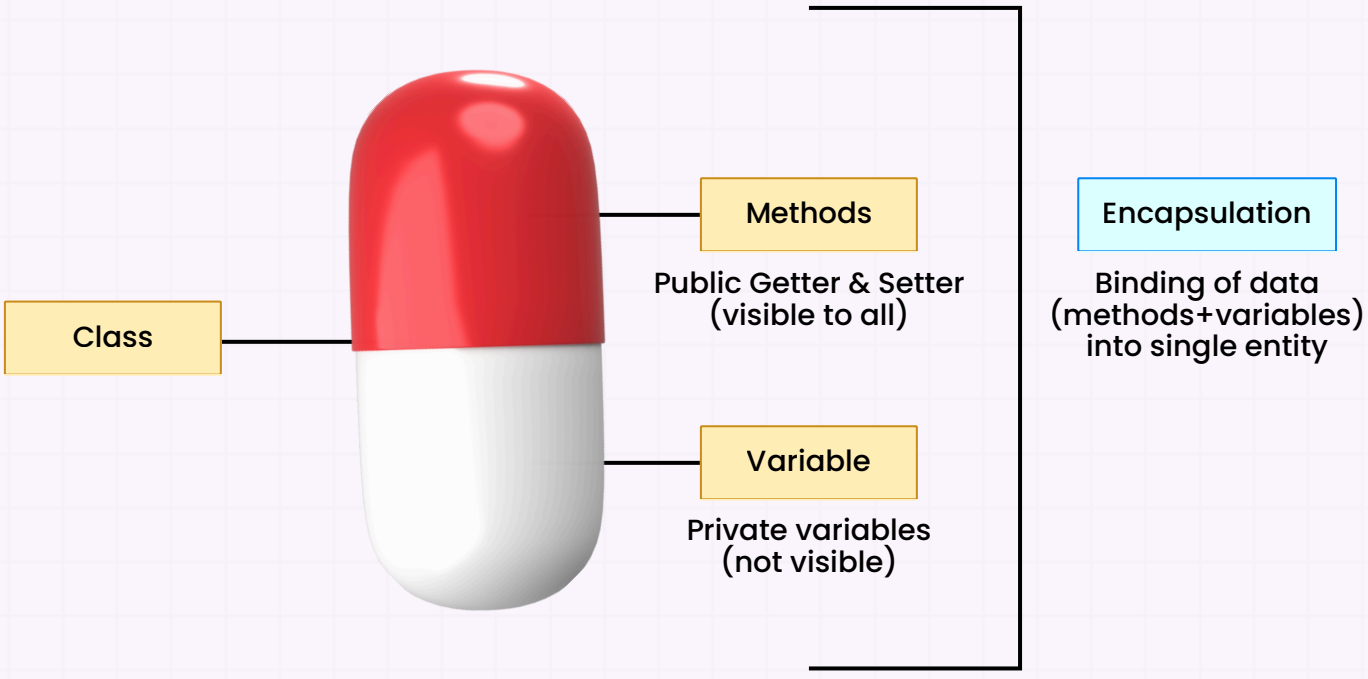
- Encapsulation refers to the bundling of data (fields) and methods (functions) that operate on the data into a single unit or class.
- It restricts direct access to certain components, protecting the integrity of the data by controlling how it is accessed and modified.

Real-Life Examples

Example 1: Medical Capsule

Imagine a medical capsule that contains different medicines mixed together.

- How it relates to Encapsulation:
  - The capsule shell represents the class in Java.
  - The medicines inside are like the private data members.
  - The capsule's outer layer (the class) protects and contains the internal components (the data).
  - Users (patients) don't need to know about the individual ingredients or how they're mixed.
  - They only interact with the capsule as a whole, similar to how we interact with public methods in a class.



Example 2: Large Organization

Think of a large corporation with multiple departments like HR, Finance, and Marketing.

- How it relates to Encapsulation:
  - The entire organization is like a class in Java.
  - Each department is similar to a private data member or method.
  - Employees in one department don't directly access or modify data from another department.
  - Communication between departments happens through official channels (like public methods in Java).
  - The outside world interacts with the company as a single entity, not with individual departments directly.

Java Example

- In Java Encapsulation is implemented using private variables and providing public getter and setter methods to access and modify these variables.
- This protects the integrity of the data and hides the details of the class implementation.

```java
public class BankAccount {
    private double balance; // Private data

    public BankAccount(double initialBalance) {
        this.balance = initialBalance;
    }

    public void deposit(double amount) {
        if (amount > 0) balance += amount;
    }

    public double getBalance() {
        return balance;
    }
}
```

In this example:

- balance and accountNumber are private variables, meaning they can't be accessed directly from outside the class.
- Public methods like getBalance(), deposit(), and withdraw() provide controlled access to these private variables.
- The internal implementation of how the balance is stored and modified is hidden from the outside world, demonstrating encapsulation.

2. Inheritance

- Inheritance is the mechanism by which one class (the child or subclass) inherits properties and behaviors from another class (the parent or superclass).
- This enables code reuse and helps maintain hierarchical relationships between classes.

Real-Life Examples

Example 1: Vehicle Hierarchy

Consider different types of vehicles on the road.

- How it relates to Inheritance:
  - "Vehicle" would be the parent class.
  - Cars, bicycles, and buses are child classes that inherit from Vehicle.
  - All vehicles share common properties (like having wheels, a method of propulsion).
- Each specific type of vehicle adds its own unique properties:
  - Cars have doors and a trunk.
  - Bicycles have pedals and handlebars.
  - Buses have multiple rows of seats.

Example 2: Animal Kingdom

Think about different animals in nature.

- How it relates to Inheritance:
  - "Animal" would be the parent class.
  - Dogs, cats, and horses are child classes that inherit from Animal.
  - All animals share common properties (like needing food, having a lifespan).
- Each specific animal adds its own unique properties:
  - Dogs can bark and wag their tails.
  - Cats can purr and retract their claws.
  - Horses can gallop and neigh.

Animals

Java Example

- In Java Inheritance is implemented using the extends keyword.
- A subclass inherits all non-private members (fields, methods, and nested classes) from its superclass.
- Constructors are not inherited, but the subclass can call the superclass constructor using super().

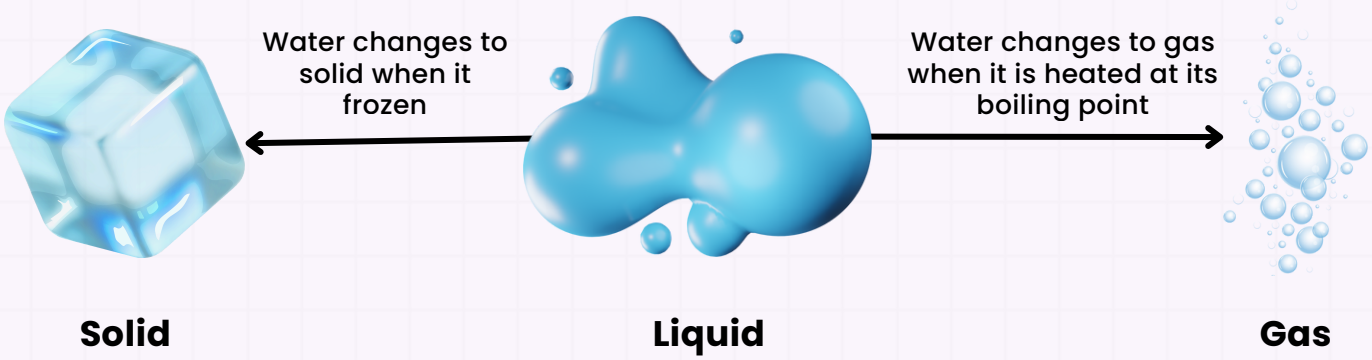
```java
// Superclass
class Vehicle {
    public void start() { System.out.println("Vehicle starting"); }
}

// Subclass
class Car extends Vehicle {
    private int numberOfDoors;

    public Car(String brand, int year, int numberOfDoors) {
        super(brand, year);  // Call to superclass constructor
        this.numberOfDoors = numberOfDoors;
    }

    public void honk() { System.out.println("Car honking"); }

    // Overriding the superclass method
    @Override
    public void start() {
        System.out.println("The car is starting");
    }
}
```

In this example:

- Car is a subclass of Vehicle, inheriting its properties and methods.
- Car adds its own property (numberOfDoors) and method (honk()).
- Car overrides the start() method to provide its own implementation.
- The super() call in the Car constructor ensures proper initialization of inherited properties.

3. Polymorphism

- Polymorphism allows one object to take many forms.
- In Java, polymorphism is primarily achieved through method overloading (compile-time polymorphism) and method overriding (runtime polymorphism).

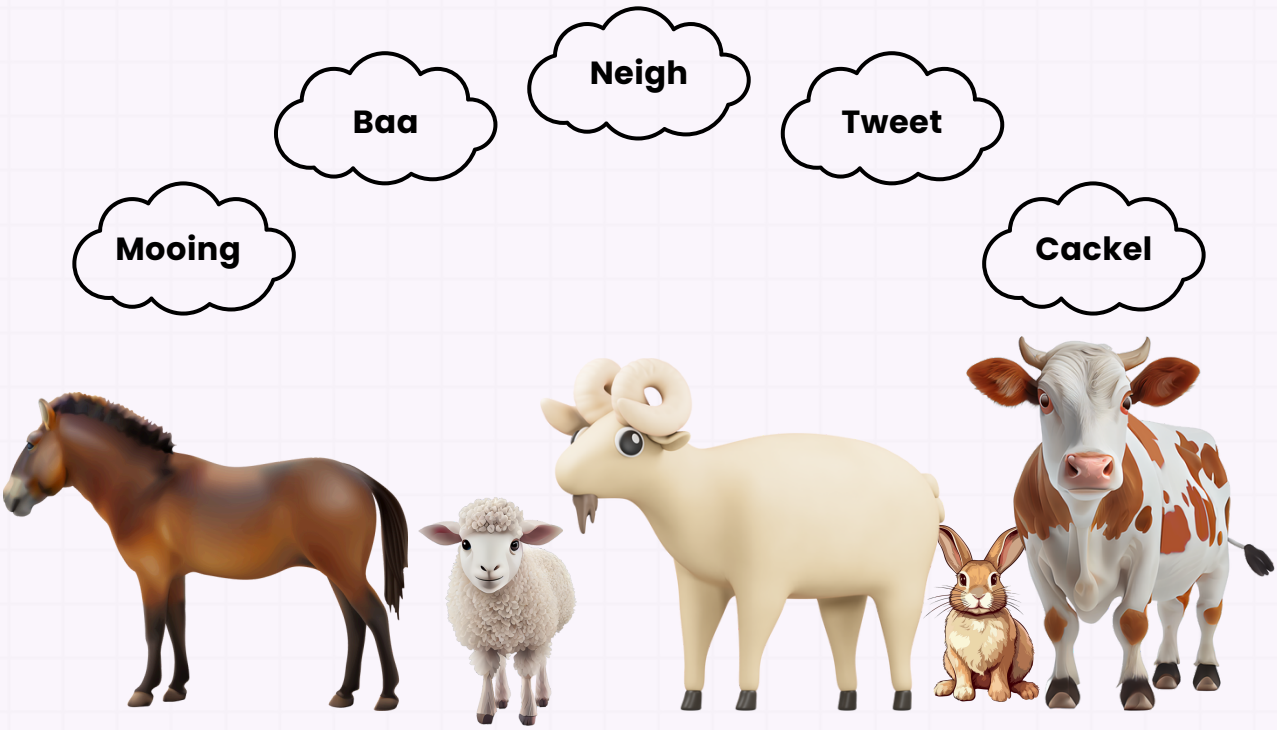


Real-Life Examples

Example 1: Sound of Animals

Think about how a single person plays different roles in different contexts.

- How it relates to Polymorphism:
  - A person can be a student, a teacher, and a parent.
- The same individual behaves differently in each role:
  - As a student, they attend classes and submit assignments.
  - As a teacher, they prepare lessons and grade papers.
  - As a parent, they care for their children and manage household responsibilities.
  - This is similar to how an object in Java can be treated as different types depending on the context, exhibiting different behaviour's.



Sound of Animals

Example 2: A Person's Roles

Think about different animals in nature.

- How it relates to Inheritance:
  - "Animal" would be the parent class.
  - Dogs, cats, and horses are child classes that inherit from Animal.
  - All animals share common properties (like needing food, having a lifespan).
- Each specific animal adds its own unique properties:
    - Dogs can bark and wag their tails.
    - Cats can purr and retract their claws.
    - Horses can gallop and neigh.
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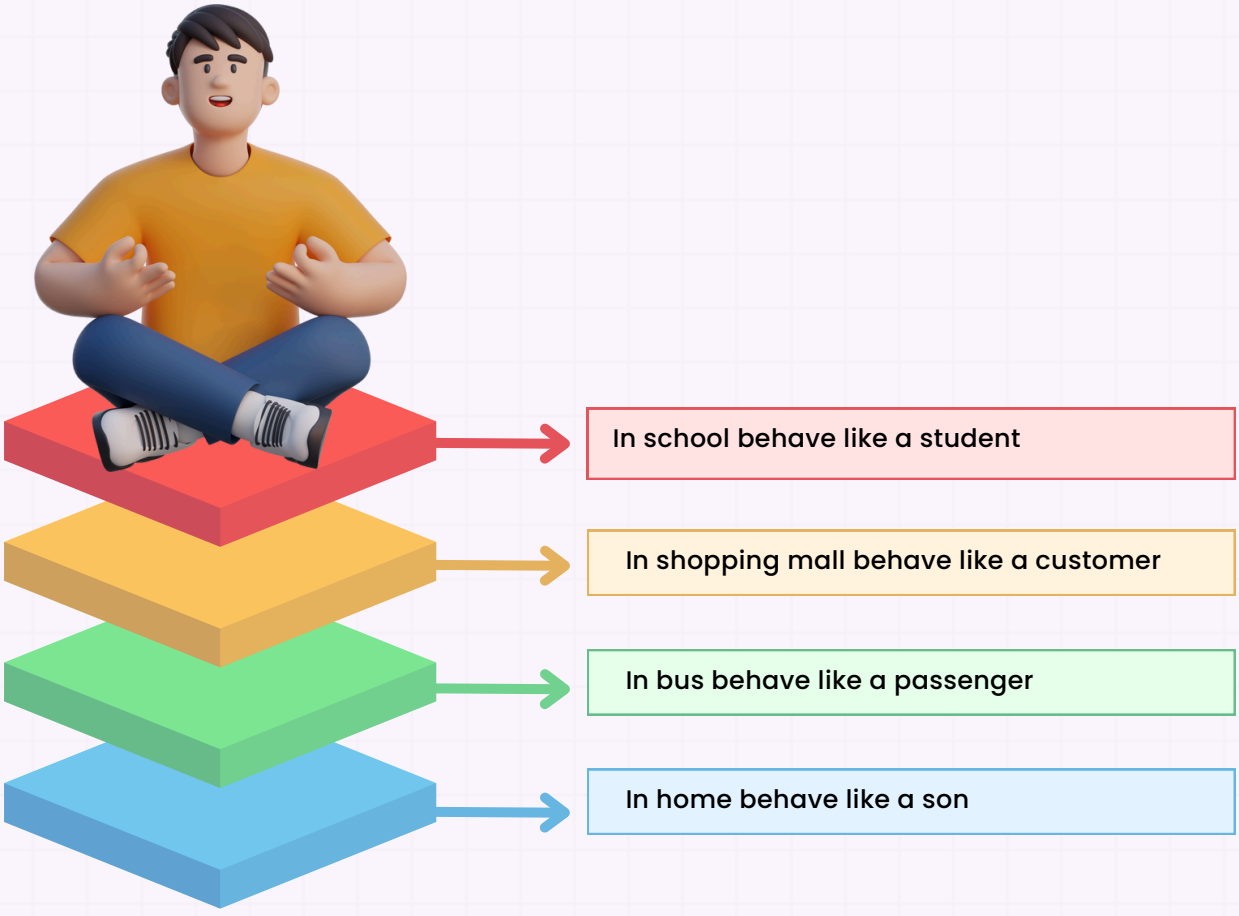


Java Example

- Method Overloading is achieved by defining multiple methods with the same name but different parameters in the same class.
- Method Overriding is implemented by providing a new implementation for a method in a subclass that is already defined in its superclass.

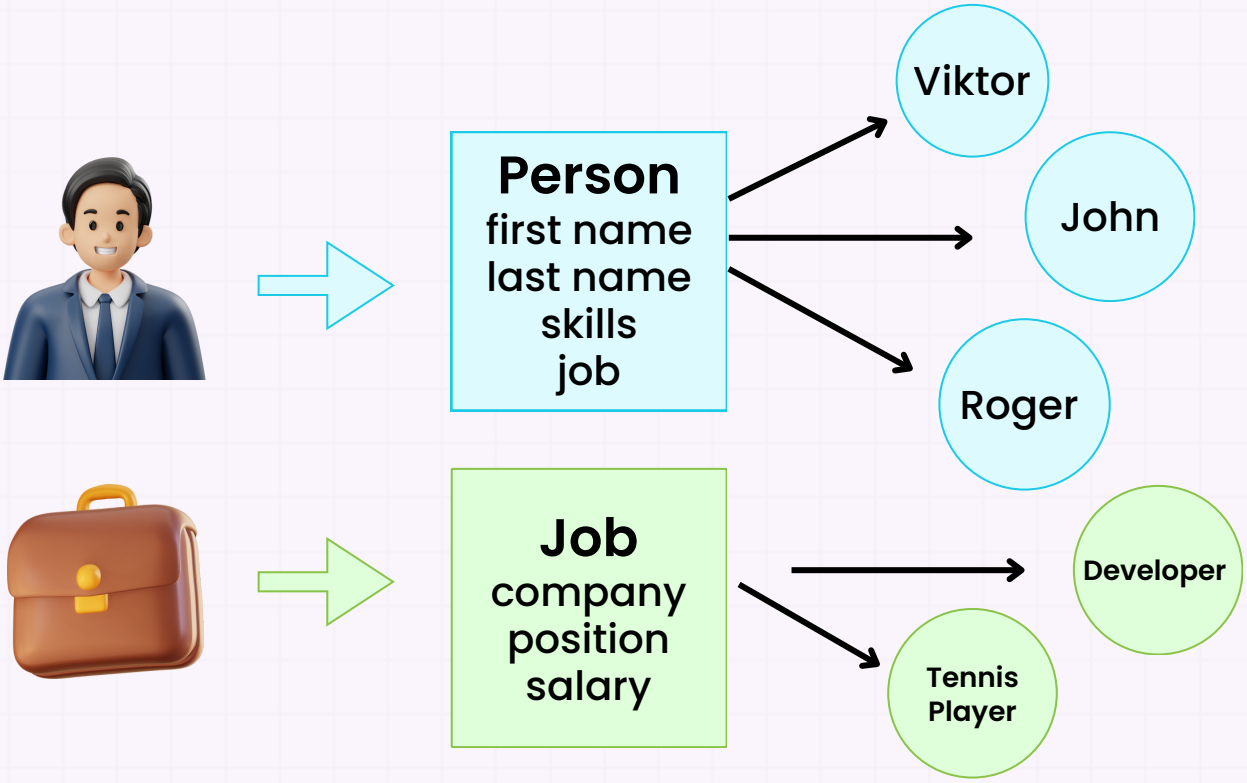
```java
class Shape {
    public double calculateArea(double radius) { return Math.PI * radius * radius; } // Circle
    public double calculateArea(double length, double width) { return length * width; } // Rectangle
}

class Circle extends Shape {
    private double radius;
    public Circle(double radius) { this.radius = radius; }
    @Override
    public double calculateArea() { return Math.PI * radius * radius; }
}

class Rectangle extends Shape {
    private double length, width;
    public Rectangle(double length, double width) { this.length = length; this.width = width; }
    @Override
    public double calculateArea() { return length * width; }
}
```

In this example:

- Overloading: calculateArea in Shape for different parameters.
- Overriding: calculateArea in Circle and Rectangle provide specific implementations.

4. Abstraction

- Abstraction involves hiding the complex internal workings of a system and exposing only what is necessary for the user.
- This helps simplify complex systems by focusing on what the user needs to know.



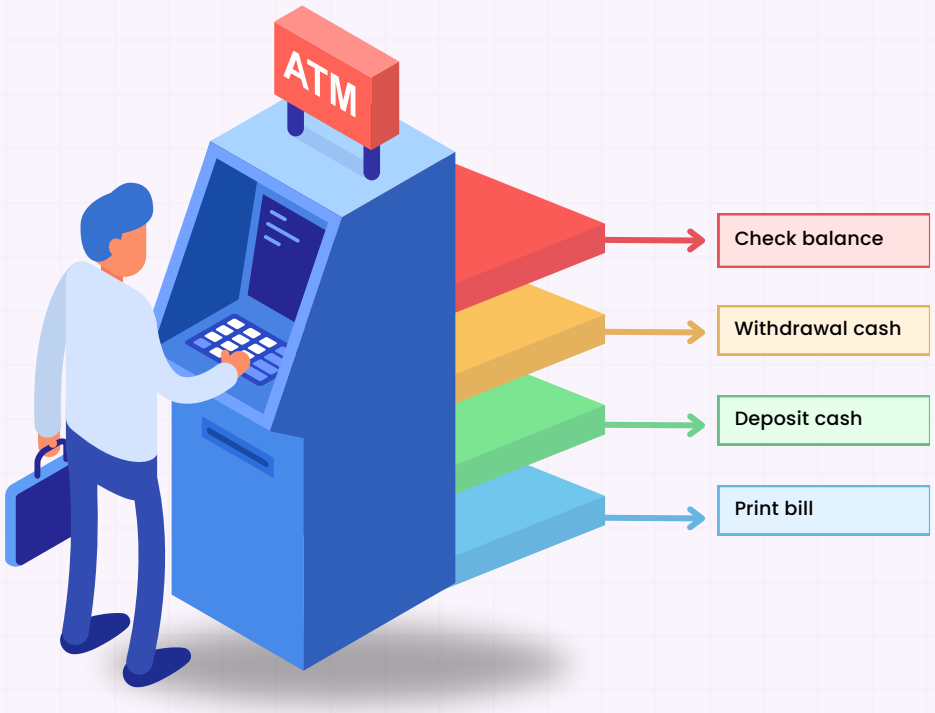
Abstraction

Real-Life Examples

Example 1: ATM Machine

Consider how we interact with an ATM machine.

- How it relates to Abstraction:
  - Users only see a simple interface: screen, keypad, card slot, and cash dispenser.
- They don't need to know about the complex internal processes:
  - How the ATM communicates with the bank's servers.
  - How it verifies account details and processes transactions.
  - How it manages its internal cash supply.
  - Users only need to know which buttons to press to perform actions like withdrawing cash or checking their balance.
  - This is like how abstract classes or interfaces in Java hide complex implementations behind simple, usable methods.



Even though it performs a lot of actions it doesn't show us the process. It has hidden its process by showing only the main things like getting inputs and giving the output.

Example 2: Mobile Phone

Think about using a smartphone.

- How it relates to Abstraction:
  - Users interact with apps through a touchscreen interface.
- They don't need to understand:
  - How the phone processes touch inputs.
  - How it renders graphics on the screen.
  - How it manages memory or processes data.
  - Users simply tap icons to open apps, swipe to navigate, or pinch to zoom.
  - This abstraction of complex processes behind a simple interface is similar to how Java interfaces or abstract classes work, providing a simple way to interact with complex systems.

- In Java Abstraction is implemented using abstract classes and interfaces.
- Abstract classes can have both abstract and concrete methods, while interfaces (prior to Java 8) only have abstract methods.

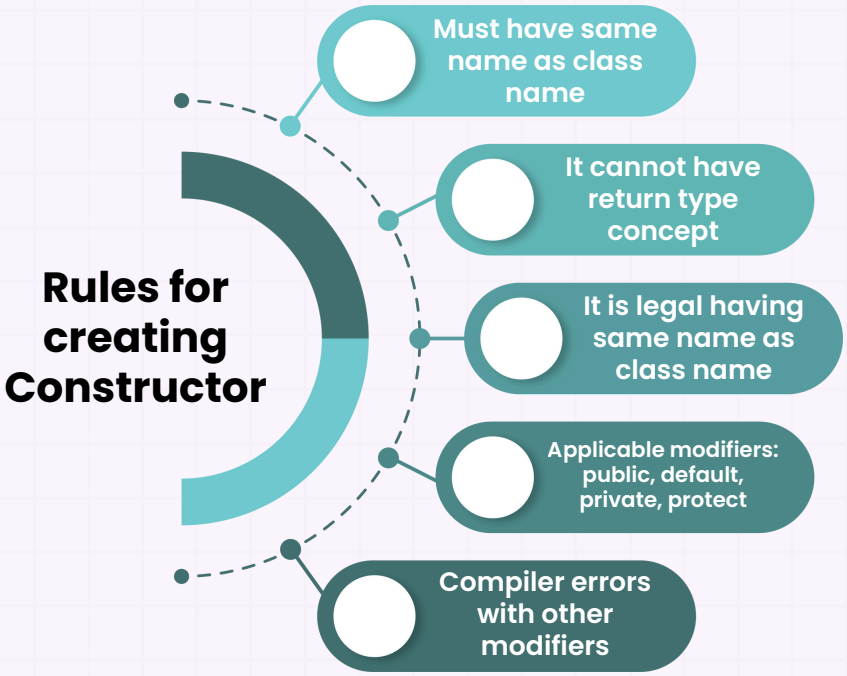
```
abstract class Device {
    public abstract void performFunction();
}

class Television extends Device {
    public void performFunction() { System.out.println("Displaying content");
}
```

In this example:

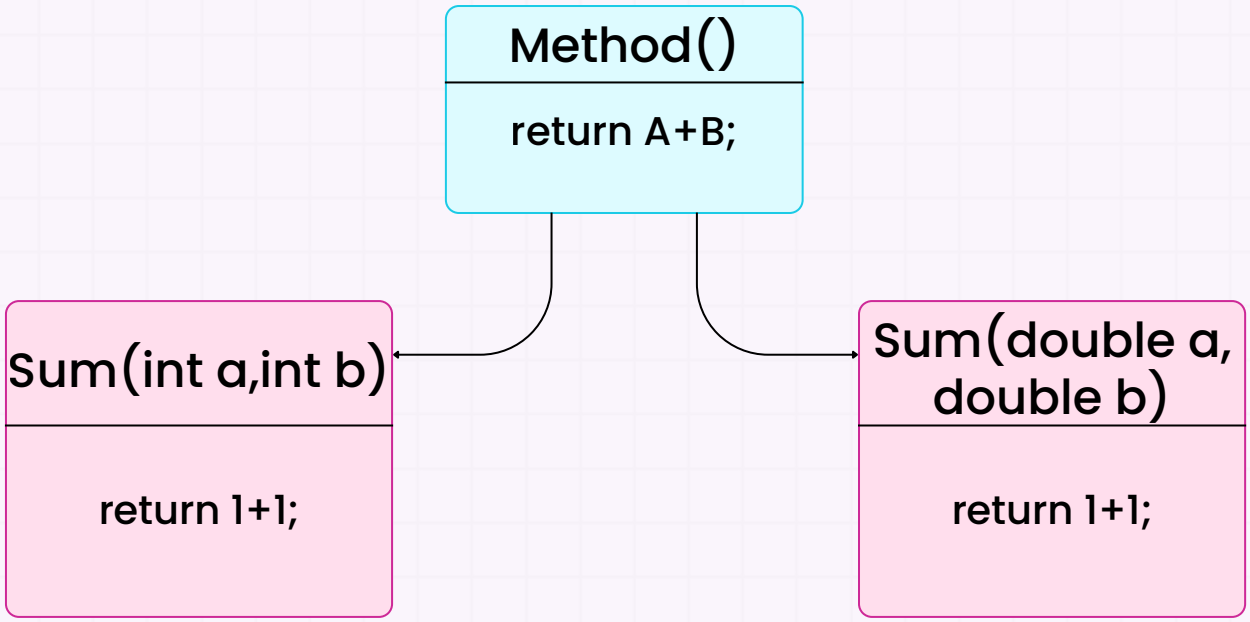
- ElectronicDevice is an abstract class with both abstract (performFunction()) and concrete (turnOn(), turnOff()) methods.
- Television is a concrete class that extends ElectronicDevice and provides an implementation for the abstract method.
- RemoteControlled is an interface defining additional behaviors.
- SmartTV demonstrates multiple inheritance by extending ElectronicDevice and implementing RemoteControlled.

5. Constructors and Overloading

- A constructor is a special method used to initialize objects.



- Constructor overloading allows a class to have more than one constructor with different parameter lists.



Overloading in Java

Real-Life Examples

Example: Pizza Ordering

Imagine ordering a pizza at a restaurant.

- How it relates to Constructors and Overloading:
  - The basic pizza (just crust and cheese) is like a default constructor.
- Adding toppings is similar to using overloaded constructors:
    - You can order a pizza with just one topping (like a constructor with one parameter).
    - Or you can order a pizza with multiple toppings (like a constructor with multiple parameters).
  - The pizza remains fundamentally the same (it's still a pizza), but its initialization (how it's made) varies based on your order.
  - This is analogous to how different constructors in a Java class can initialize an object in different ways, but they all create an instance of the same class.

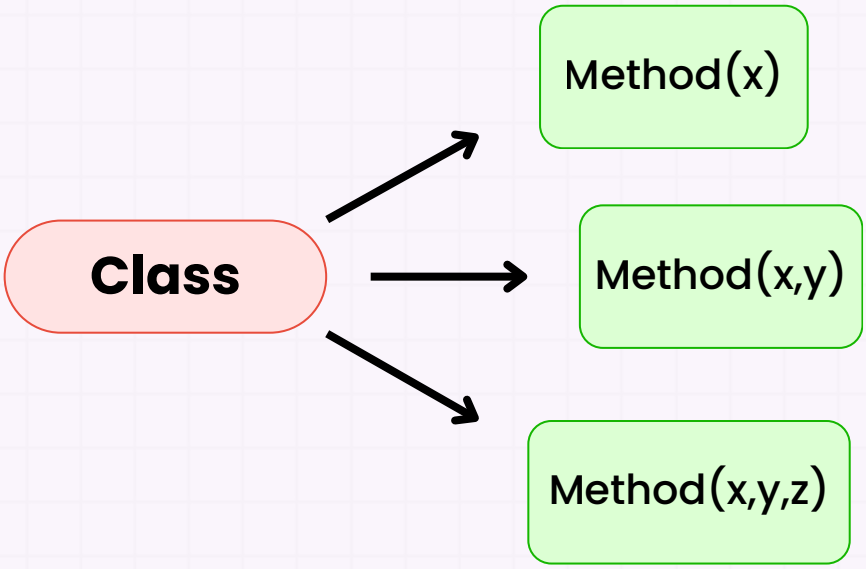
Java Example

This example shows how constructor overloading allows for flexible object creation.

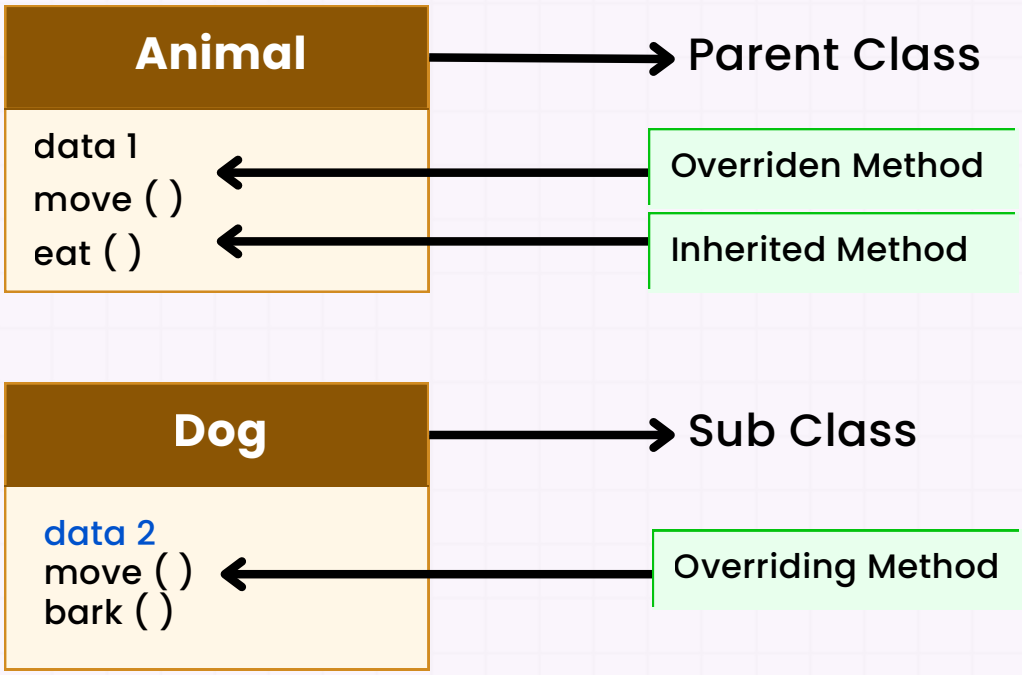
```java
public class Pizza {
    public Pizza() { System.out.println("Plain pizza"); }
    public Pizza(String... toppings) { System.out.println("Pizza with " + String.join(", ", toppings));
}
```

6. Method Overloading vs. Overriding

- Method Overloading is when multiple methods have the same name but different parameter lists.
- It occurs within the same class and is resolved at compile-time.



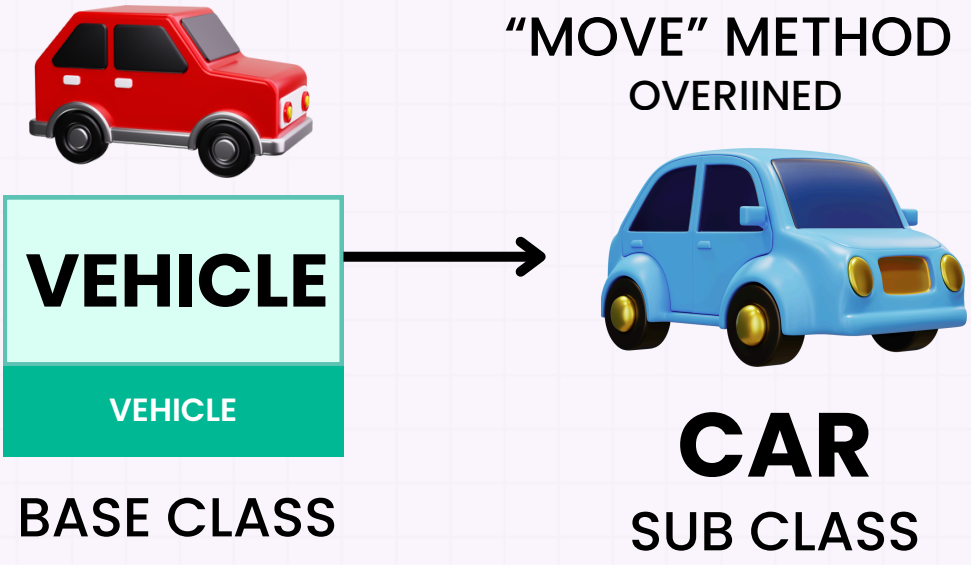
- Method Overriding is when a subclass provides a specific implementation of a method that is already defined in the parent class.
- It occurs at runtime (runtime polymorphism).



Real-Life Examples

- Overloading: Think of a printer that can print either text or images.
- Even though both methods are called "print," they handle different types of data.

- Overriding: Imagine you have a base class Vehicle that moves.
- A Car (subclass) might override this method to provide its specific way of moving.



Java Example

```java
// Overloading
class Printer {
    // Overloading
    void print(String text) {
        System.out.println("Printing text: " + text);
    }

    void print(int number) {
        System.out.println("Printing number: " + number);
    }
}

// Overriding
class Animal {
    void sound() {
        System.out.println("Animal makes a sound");
    }
}

class Cat extends Animal {
    @Override
    void sound() {
        System.out.println("Cat meows");
    }
}
```

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