Advanced Programming

Polymorphism in Java — Extended Edition

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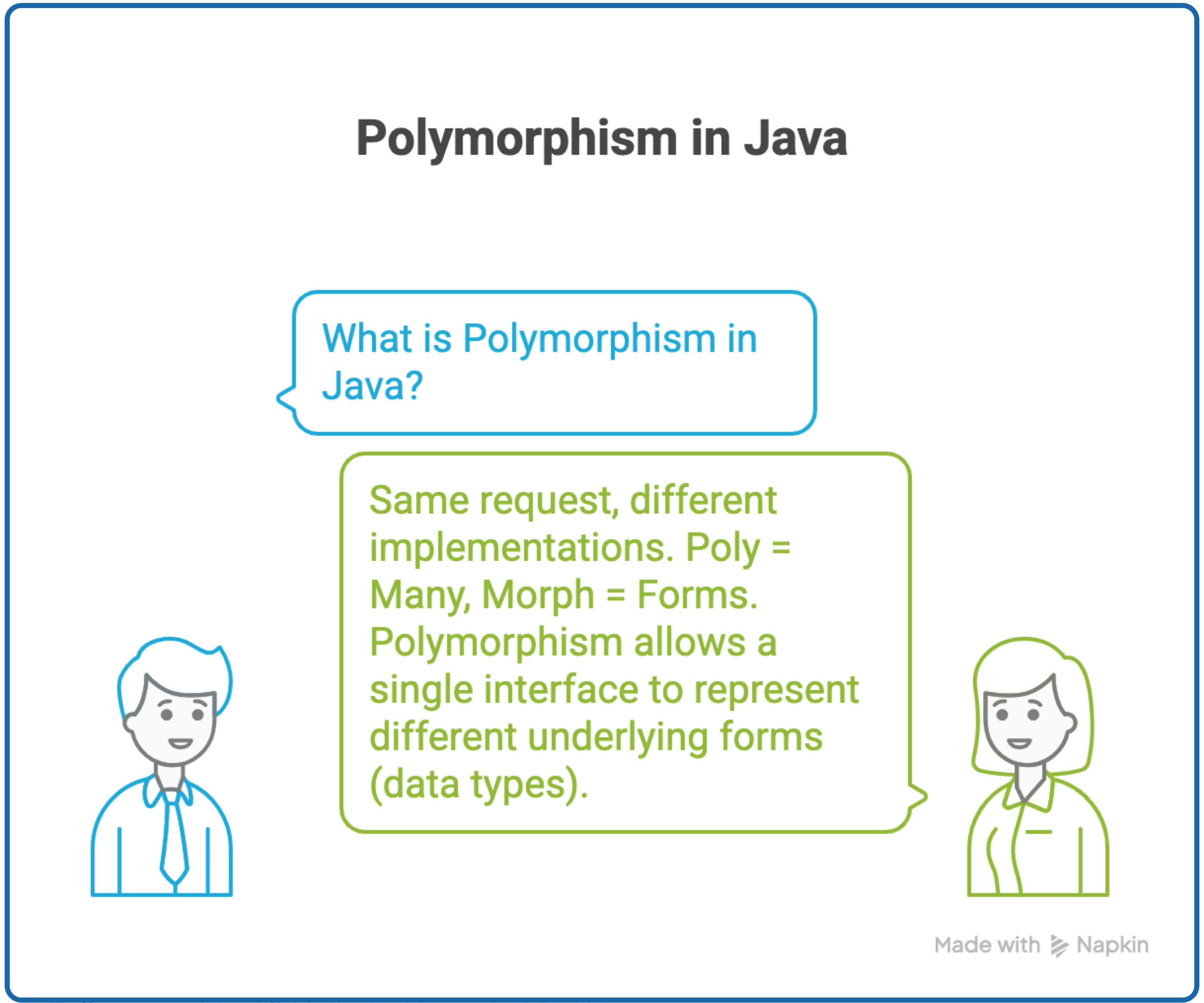


Polymorphism in Java

What is Polymorphism in Java?

Same request, different implementations. Poly = Many, Morph = Forms. Polymorphism allows a single interface to represent different underlying forms (data types).

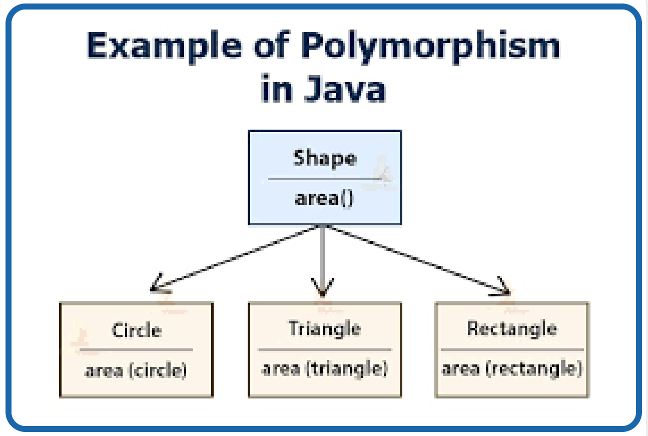
Polymorphism — Concept

- **Polymorphism** = “many forms”
- Same method name, **different behavior**
- Enables flexibility and **code reuse**

Two types:

1. **Compile-time (Static)** → *Overloading*
2. **Runtime (Dynamic)** → *Overriding*

> JVM decides which method to call at runtime for overriding.



Compile-time Polymorphism — Method Overloading

```java
class Printer {
    void print(int value) {System.out.println("Integer: " + value);}
    void print(String value) {System.out.println("String: " + value);}
    void print(double value, int count) {
        System.out.println("Double: " + value + ", count: " + count);
    }
}
```

```java
Printer p = new Printer();
p.print(42);
p.print("Sharif");
p.print(3.14, 2);
```

> Same method name, different **parameter list**.
>
> Return type alone cannot differentiate methods.

Notes — Overloading Rules

Rule	Description
Name & Parameters	Must be identical to parent’s method
Return Type	Same or covariant (subtype allowed)
Access Modifier	Can be wider, not more restrictive
Exceptions	Only same or subclass checked exceptions
Occurs	Happens at **compile** (compile-time polymorphism)
@Overload	Optional but strongly recommended

> The compiler picks the best match for the arguments.

Runtime Polymorphism — Method Overriding

```java
class Animal {
    void sound() { System.out.println("Animal sound"); }
}

class Dog extends Animal {
    @Override
    void sound() { System.out.println("Woof"); }
}

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

```java
Animal a1 = new Dog();
Animal a2 = new Cat();
a1.sound(); // Woof
a2.sound(); // Meow
```

> Same method signature, different implementations.
>
> Happens **at runtime** through *dynamic method dispatch*.

Rules — Method Overriding

Rule	Description
Name & parameters	Must match exactly with parent method
Return type	Same or subtype (covariant)
Access modifier	Can’t be more restrictive than parent
Static / final	These methods can’t be overridden
Occurs	Happens at **runtime** (runtime polymorphism)

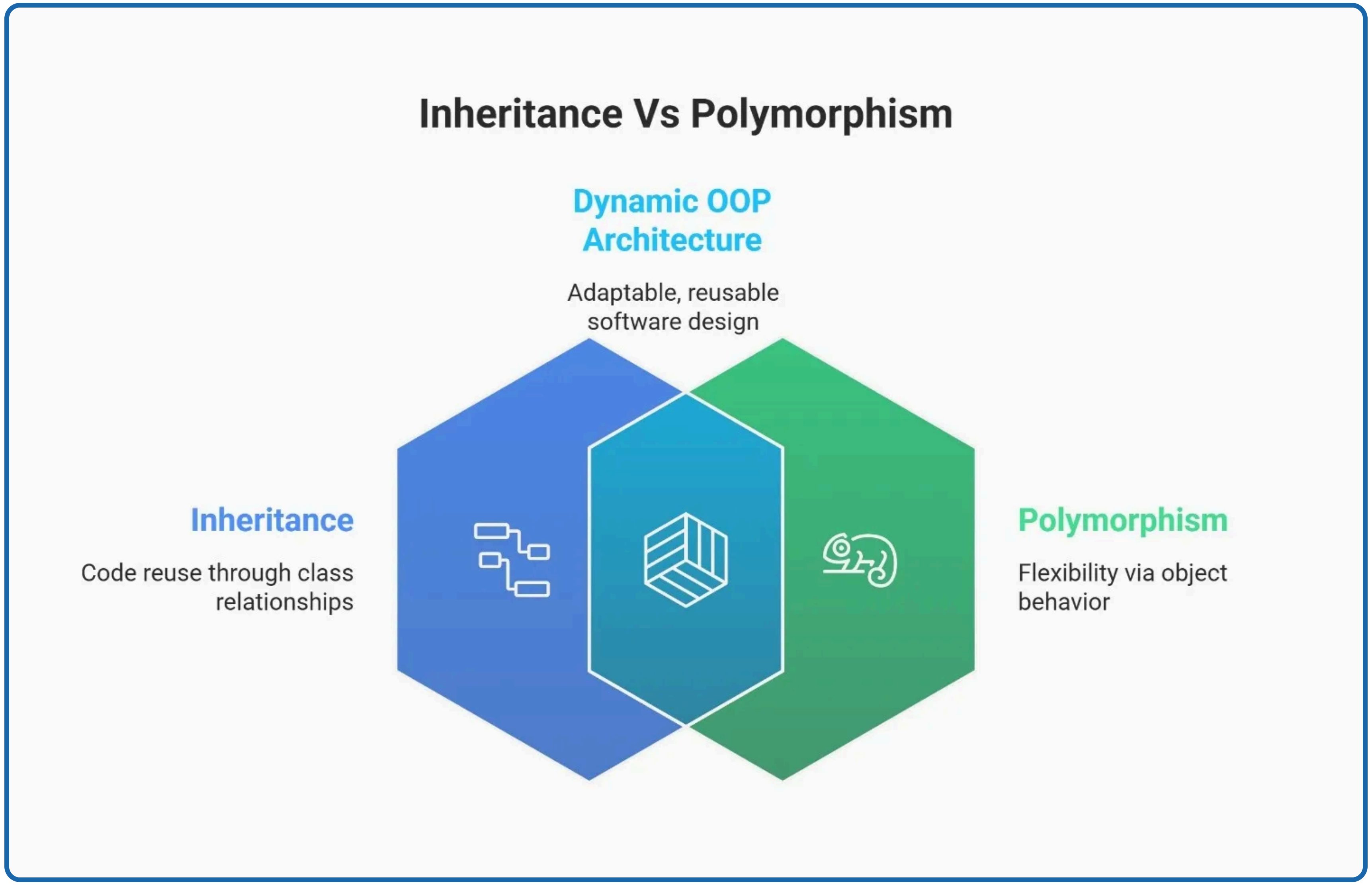
> Use `@Override` annotation to avoid mistakes.

How Polymorphism Works with Inheritance

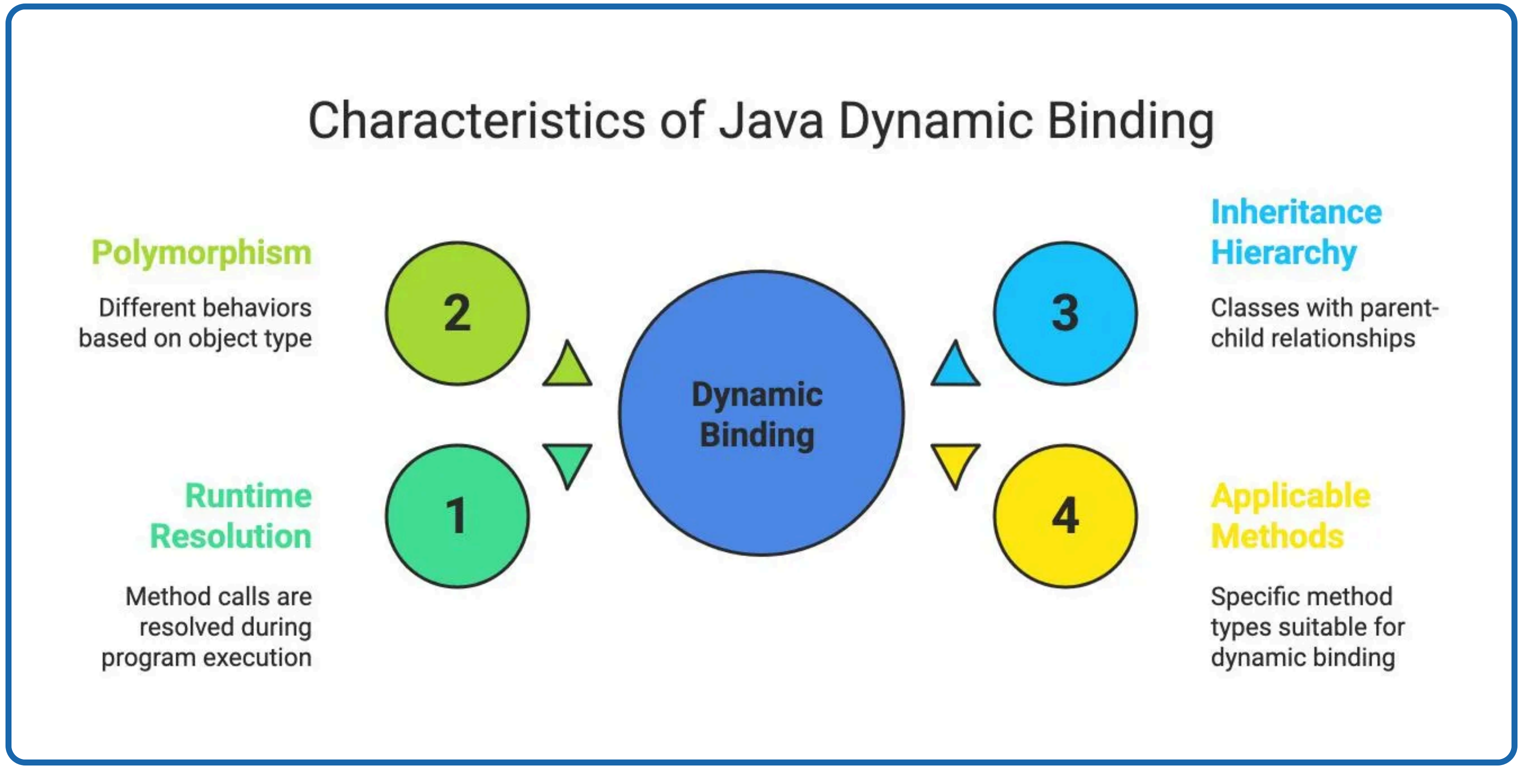
- Inheritance → **structure and reusability**
- Polymorphism → **behavioral flexibility**

```java
Animal a = new Dog();
a.sound(); // Executes Dog’s method
```

> The reference type determines available members,
> but the **object type** determines which method runs.


Inheritance Vs Polymorphism
Dynamic OOP Architecture
Adaptable, reusable software design
Inheritance
Code reuse through class relationships
Polymorphism
Flexibility via object behavior

Visualizing Dynamic Binding

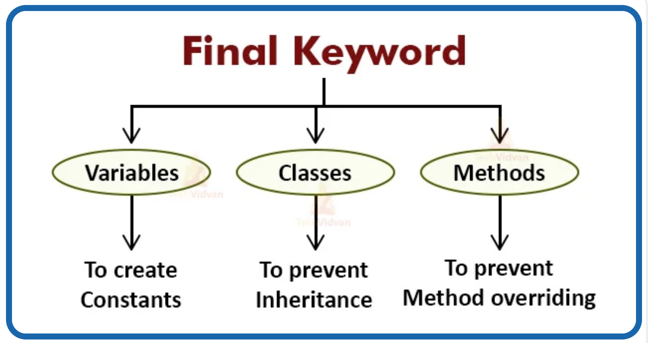

Characteristics of Java Dynamic Binding
Polymorphism
Different behaviors based on object type
2
Runtime Resolution
Method calls are resolved during program execution
1
Dynamic Binding
3
Inheritance Hierarchy
Classes with parent-child relationships
4
Applicable Methods
Specific method types suitable for dynamic binding

- Compiler binds by **reference type**
- JVM executes by **object type**

The `final` Keyword — Restrictions

- **final variable** → cannot change value
- **final method** → cannot be overridden
- **final class** → cannot be subclassed

Used for **security, performance**, and **immutability**.



Examples — `final` Usage

```java
final class Animal {}  // cannot have subclass
class Dog {
    final void bark() {
        System.out.println("Woof!");
    }
}
```

```java
class Zoo {
    final String name = "Sharif Zoo";
    void display() {
        // name = "Tehran Zoo"; // not allowed
        System.out.println(name);
    }
}
```

> `final` = permanent → protects design integrity.

Overloading vs Overriding — Summary

Feature	Overloading	Overriding
Binding time	Compile-time	Runtime
Method name	Same	Same
Parameters	Must differ	Must match exactly
Return type	Can differ	Must be same or covariant
Access level	Can change freely	Can’t reduce visibility
Inheritance required	No	Yes
Purpose	Same action, different inputs	Change inherited behavior

Real-world Example

```java
class Payment {
    void pay() { System.out.println("Generic payment"); }
}
class CreditCard extends Payment {
    @Override
    void pay() { System.out.println("Paying via Credit Card"); }
}
class PayPal extends Payment {
    @Override
    void pay() { System.out.println("Paying via PayPal"); }
}
public class Checkout {
    public static void main(String[] args) {
        Payment p = new CreditCard();
        p.pay();
        p = new PayPal();
        p.pay();
    }
}
```

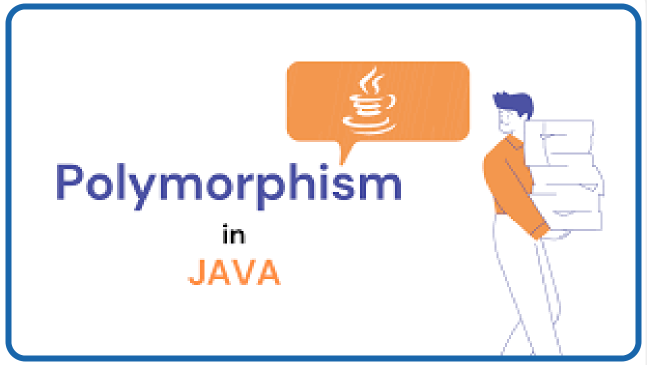
Summary

Concept	Description
Overloading	Compile-time polymorphism — same method name, different parameters
Overriding	Runtime polymorphism — child redefines parent method
Dynamic Binding	Actual object type decides which method runs at runtime
final	Prevents overriding or inheritance of classes/methods
Inheritance	Foundation for code reuse and polymorphism

> Polymorphism + Inheritance = Core of OOP flexibility.

Thank You!

Polymorphism in Java — Extended



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