SEO & Marketing Icons

Introduction to
Design Patterns

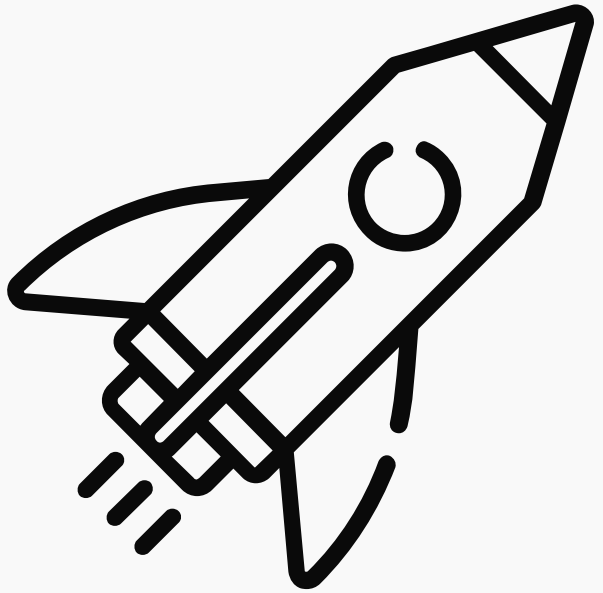

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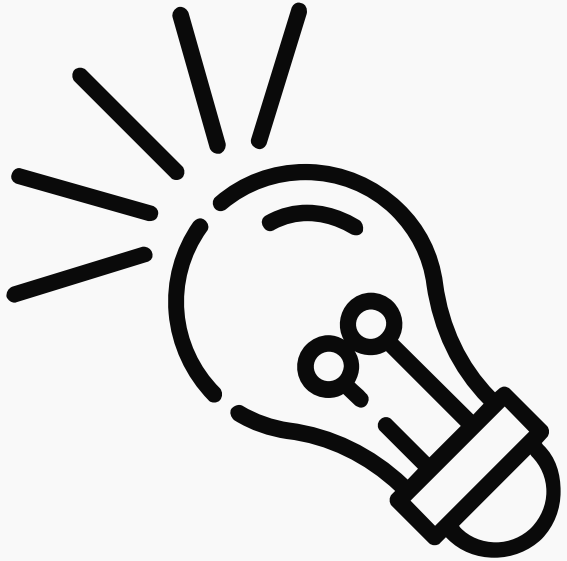
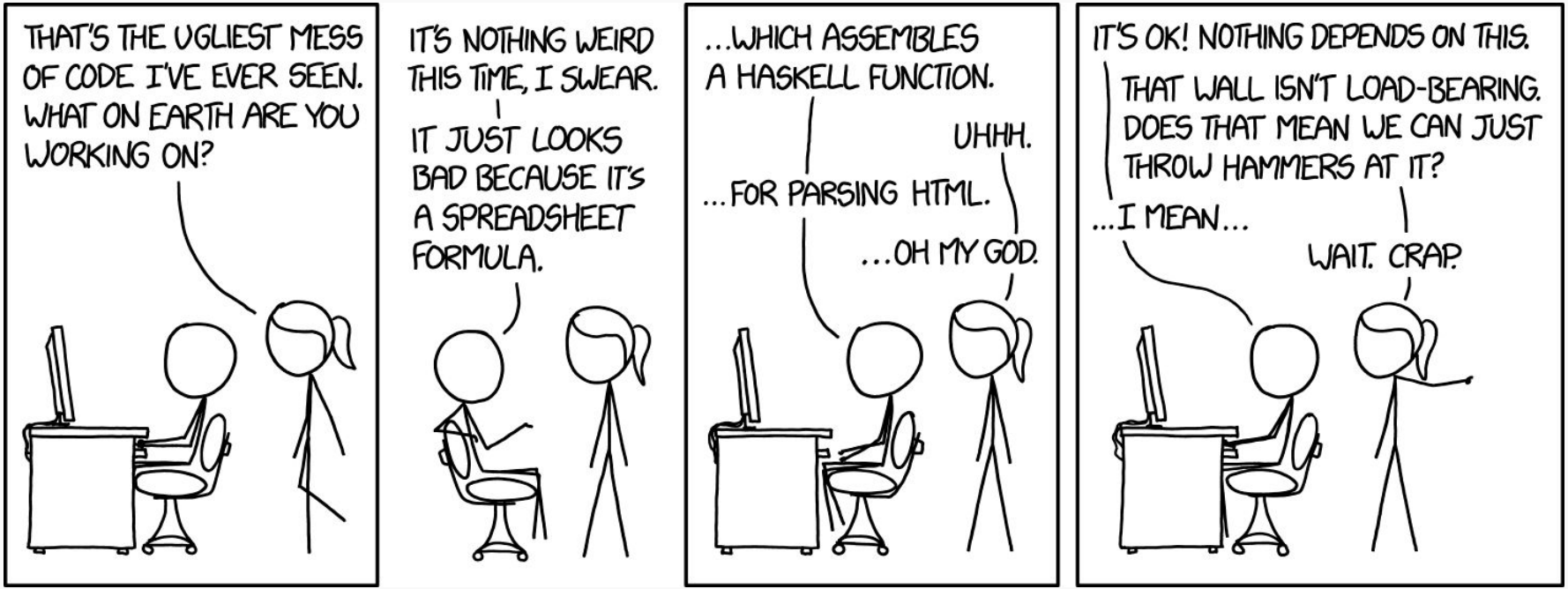
Table of contents

01

Why Do We Need Design Patterns?

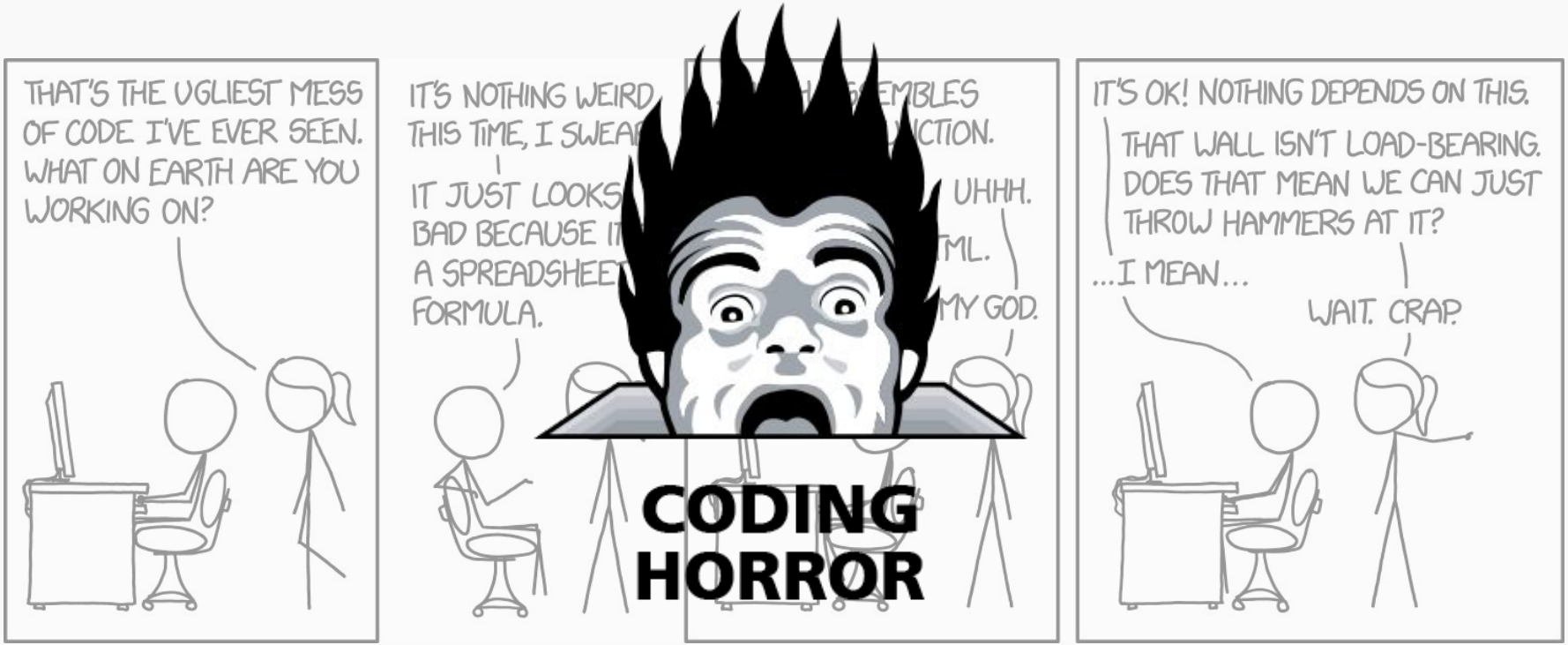


We want to avoid this



(xkcd: Bad Code)

We want to avoid this



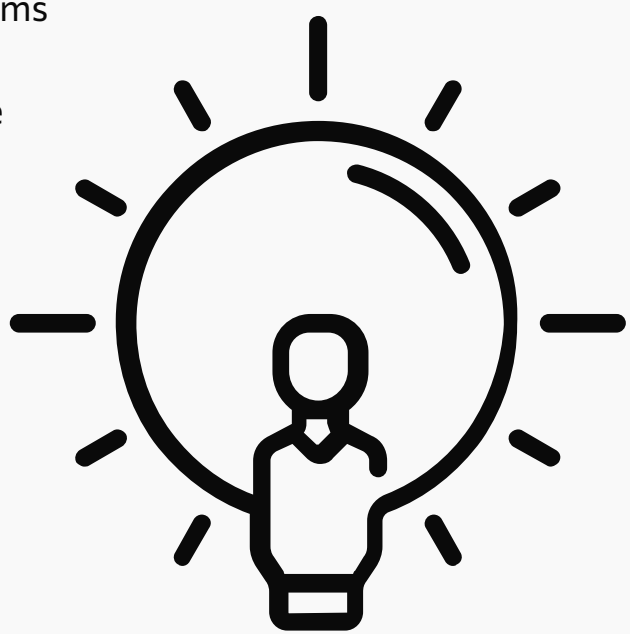
(xkcd: Bad Code)

Why Do We Need Design Patterns?

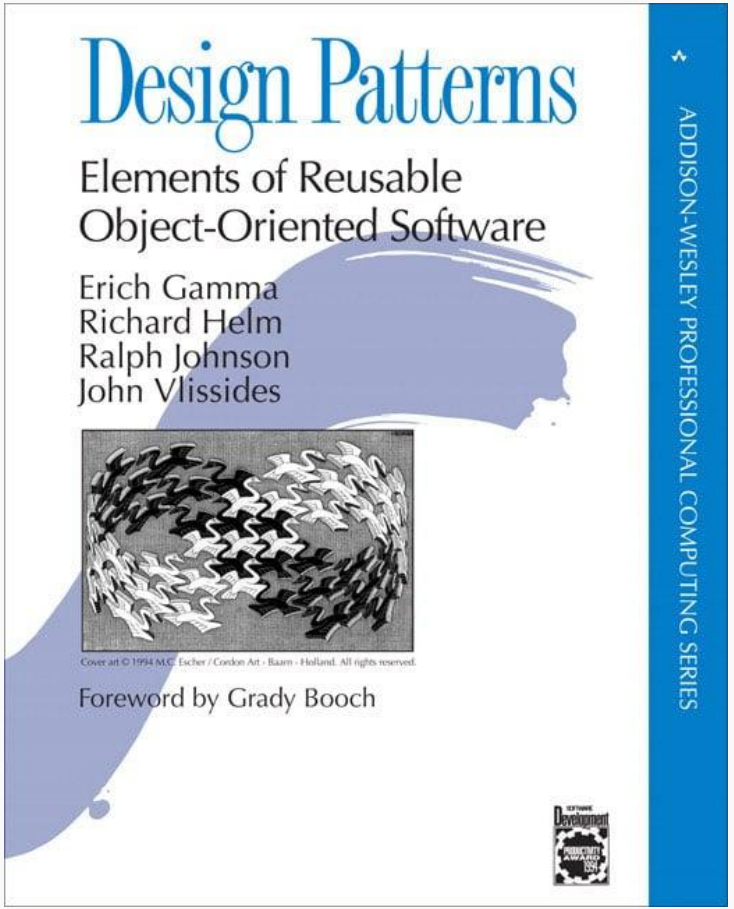
- Software development is complex
- Without structure, code becomes hard to maintain
- Common problems appear repeatedly

Why Do We Need Design Patterns?

- Design Patterns are reusable solutions to common problems
- Provide proven best practices
- Help write code that is scalable, maintainable, and flexible



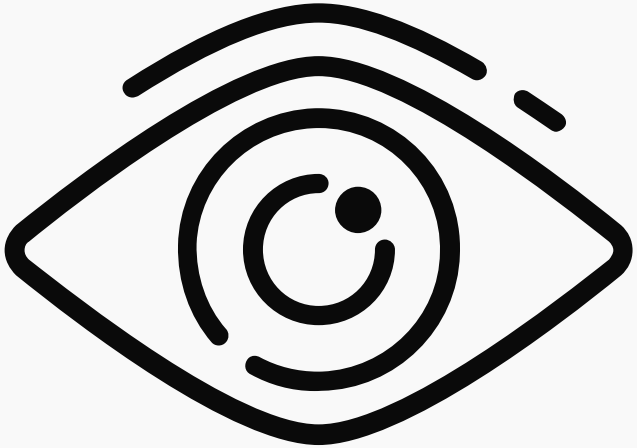
- (Almost) everything covered in these slides stems from this book.
- Recommended read if interested in more



02

Classification

Why design patterns are important



Classification

Creational

Deal with object creation

Behavioural

Identify common behaviours between objects

Structural

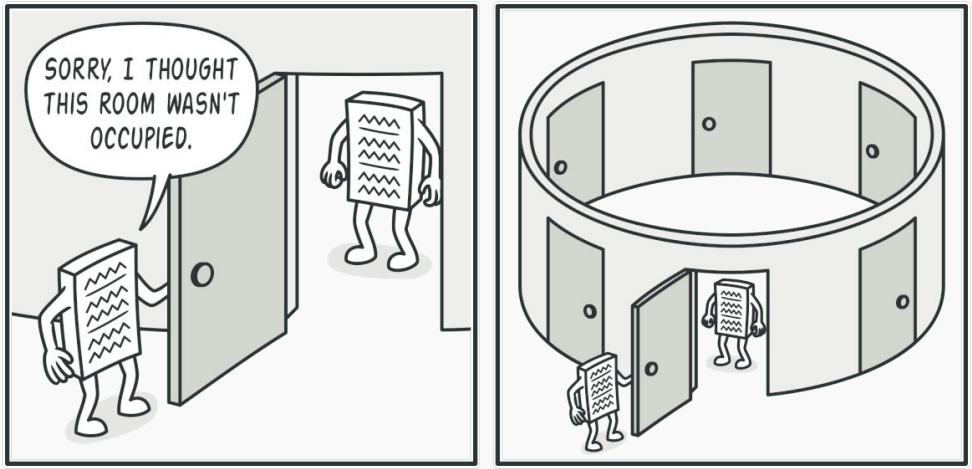
Define relationships between objects

03

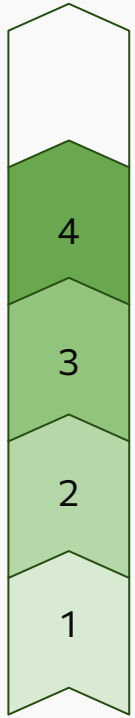
Deep dive

Singleton - Creational

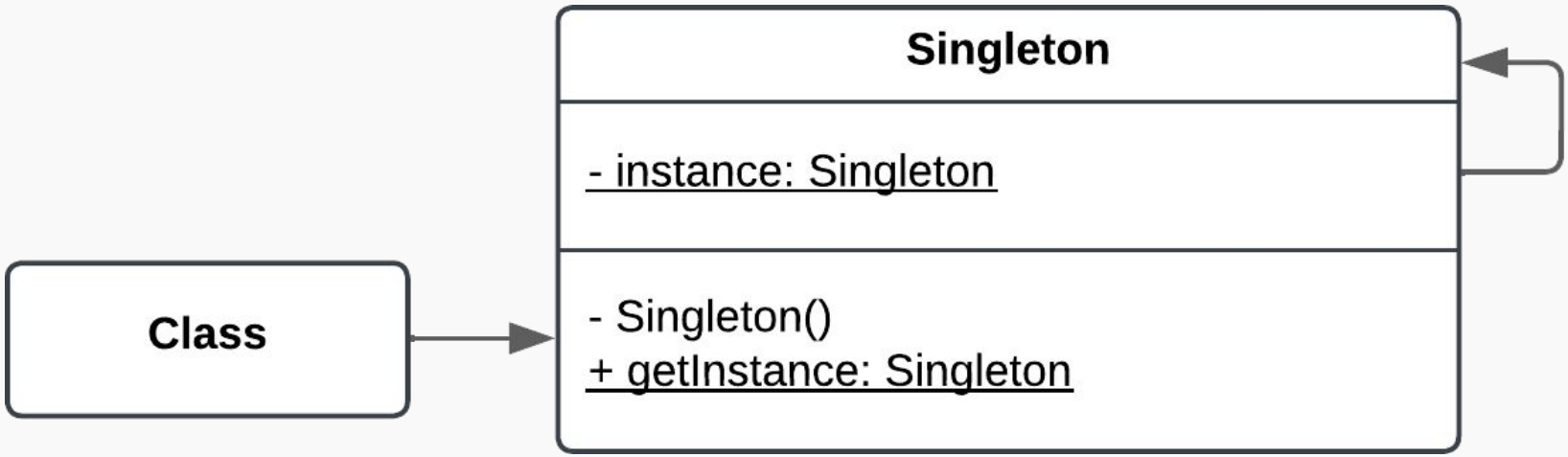
- Only one instance of the class
- Global access
- Violates Single responsibility principle



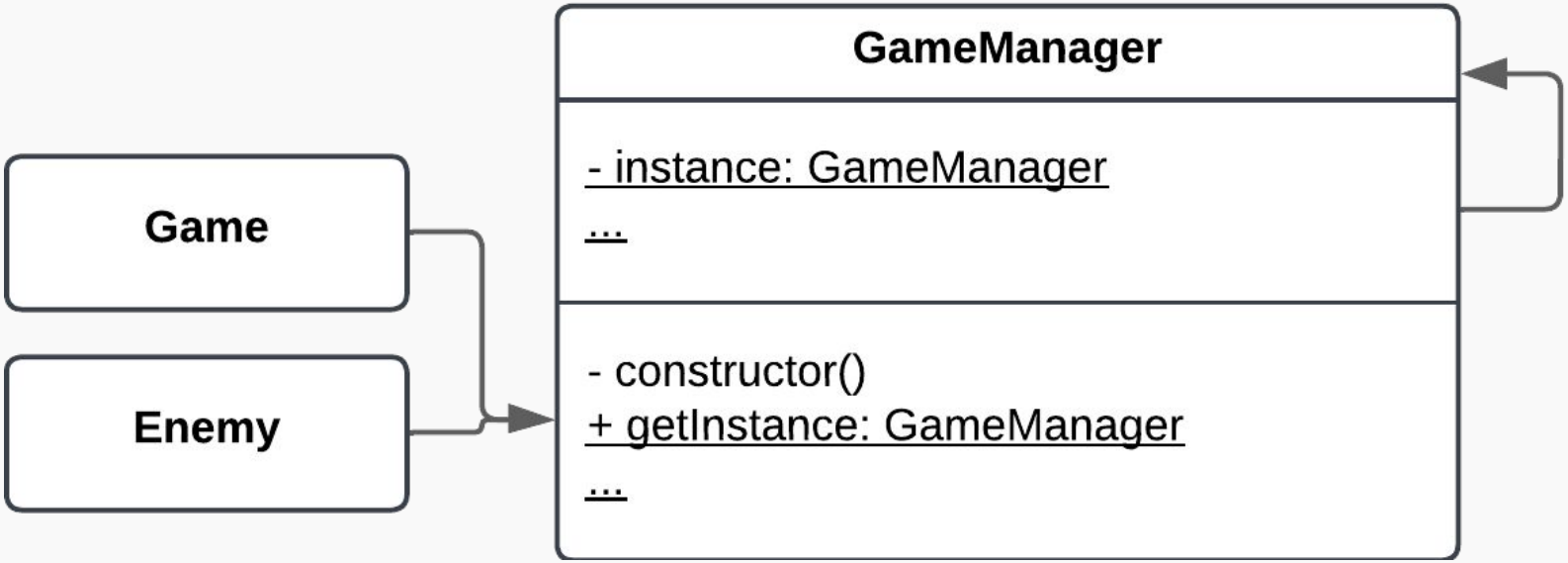
(Refactoring.Guru, 2025)



Class diagram - Generic



Class diagram - Example



Game manager Singleton

```
export class GameManager {
  private static instance: GameManager;

  private level: number;
  private inventory: string[];
  private points: number;

  public static getInstance(): GameManager {
    return GameManager.instance || (GameManager.instance = new GameManager());
  }

  private constructor() {
    this.level = 1;
    this.inventory = ['Sword', 'Potion'];
    this.points = 0;
  }
 ...
}
```

Singleton usage in game class

```
class Game {
  // Access the GameManager singleton instance. If it doesn't exist, it will be created.
  private gameManager = GameManager.getInstance();
  ...
  displayInventory(): void {
    console.log('Your inventory:');
    this.gameManager.getInventory().forEach((item) => {
      console.log(item);
    });
  }
  ...
}
```

Singleton usage in enemy class

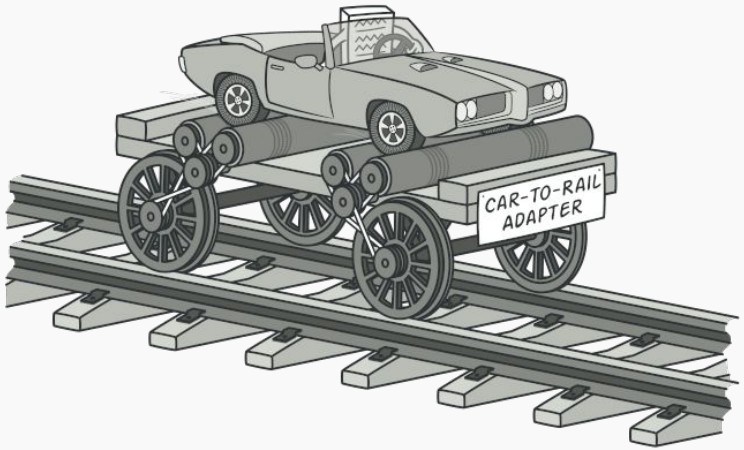
```
export class Enemy {
   ...
  defeat(): void {
    // The gameManager is accessed here. If it
    // was previously created, no new instance is created.
    let gameManager = GameManager.getInstance();
    gameManager.addPoints(this.pointValue);
  }
}
```

Singleton - Creational

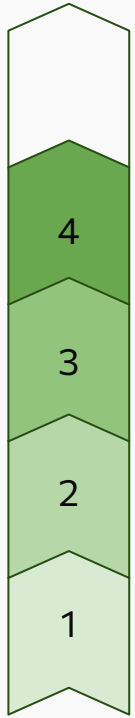
Advantages	Disadvantages
— Safe global access to data and functionality	— Violates Single responsibility principle
— Lazy initialization	— Difficult to unit test
— Assures that only one instance of the class exists	— Can turn into ‘God’ class
— Great for shared resources	— Tricky implementation in multithreaded environment

Adapter - Structural

- Allows objects with incompatible interfaces to collaborate
- It uses an adapter object to translate between interfaces
- Provides an elegant solution but increases overall complexity of the code

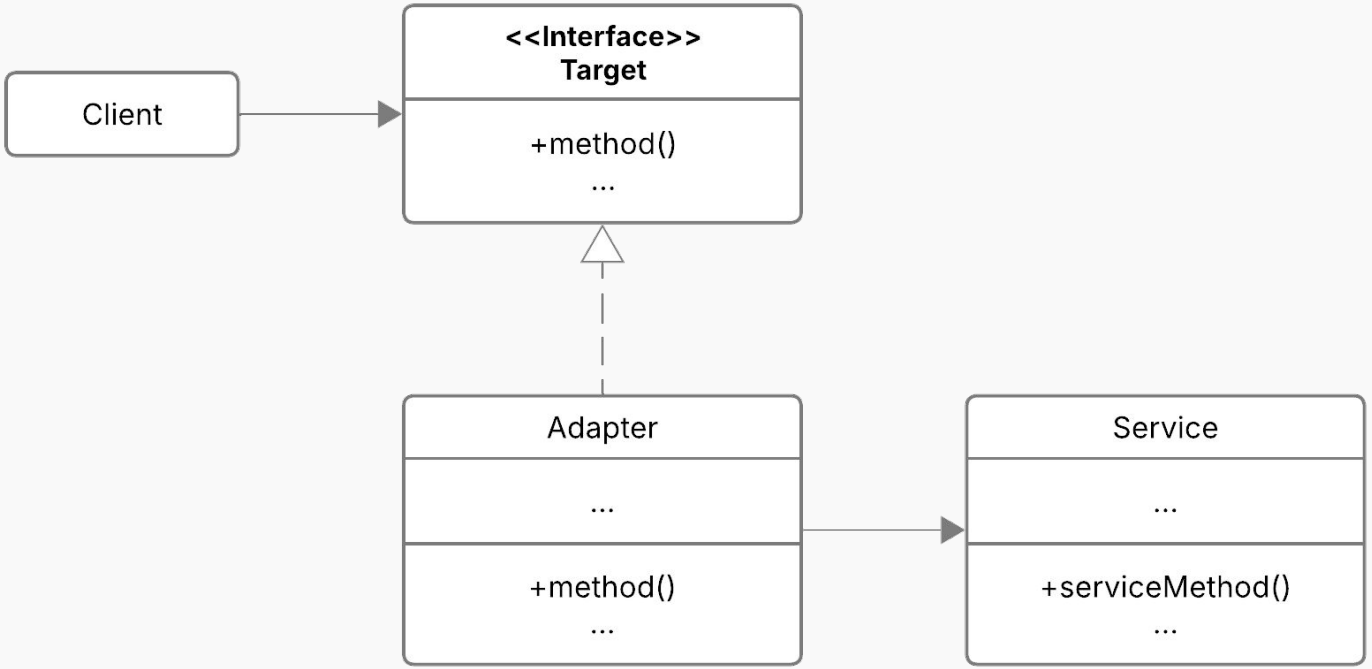


(Refactoring.Guru, 2025)

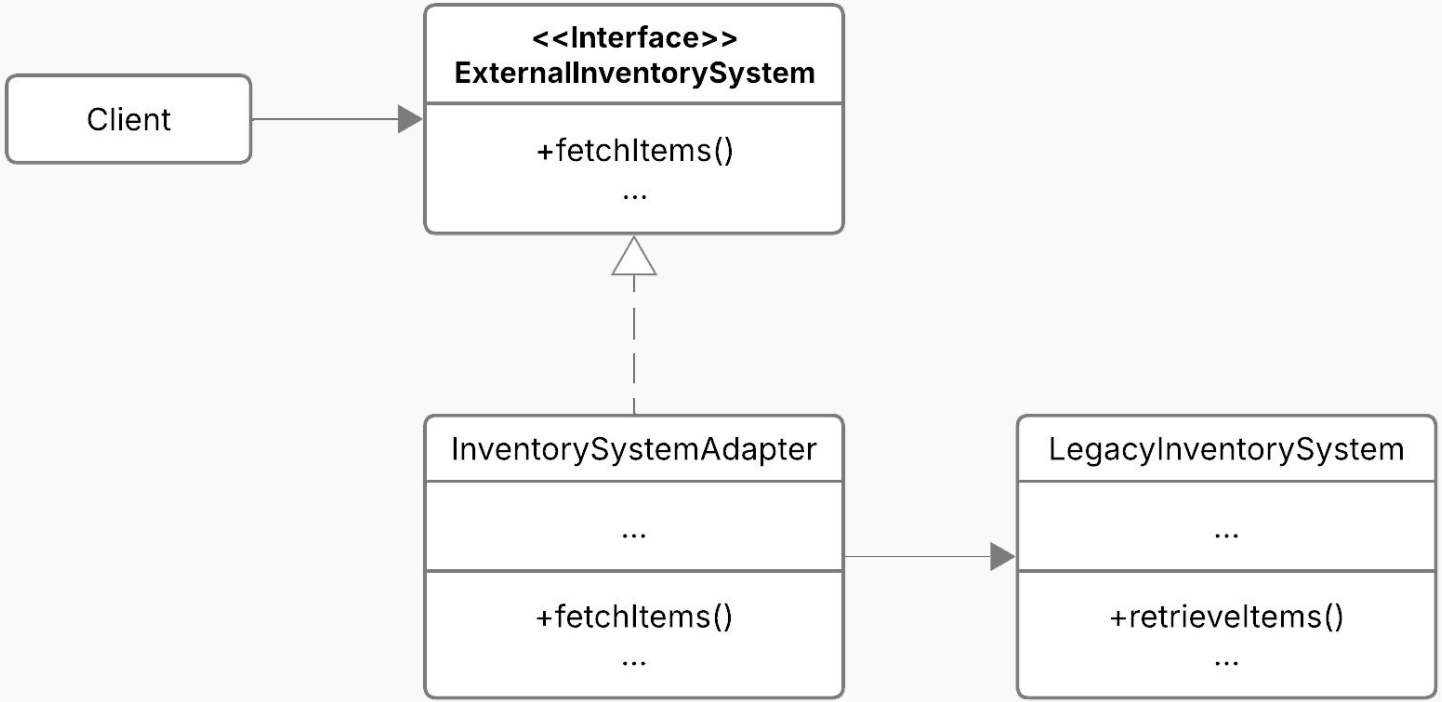


Frequency of use

Class diagram - Generic



Class diagram - Example



External inventory system

```
interface ExternalInventorySystem {
  fetchItems(): string[];
}
```

Old inventory system

```
class LegacyInventorySystem {
  retrieveItems(): string[] {
    return ['Gun', 'Ammo'];
  }
}
```

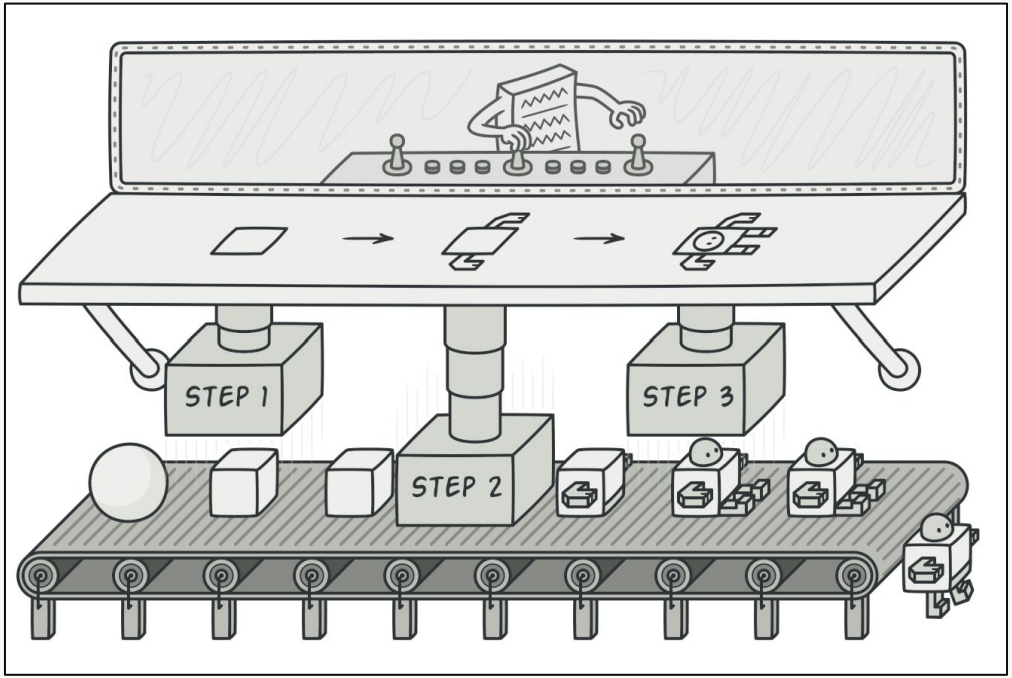
Creating the adapter

```
export class InventorySystemAdapter implements ExternalInventorySystem {
 private legacySystem: LegacyInventorySystem;
 private itemMapping: Record<string, string>;

 constructor() {
   this.legacySystem = new LegacyInventorySystem();
   this.itemMapping = {
     'Gun': 'Sword',
     'Ammo': 'Potion'
   };
 }

 fetchItems(): string[] {
   return this.legacySystem.retrieveItems().map(item => this.itemMapping[item] || item);
 }
}
```

Adapter - Structural

Advantages	Disadvantages
— Easier integration	— Adds complexity to the code
— Reusable code	— Could worsen performance
— Flexibility	— Difficult maintainability
— Single responsibility	— Doesn’t really solve design problems, just patches them up

Builder - Creational



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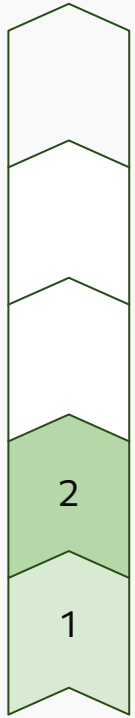


Frequency of use

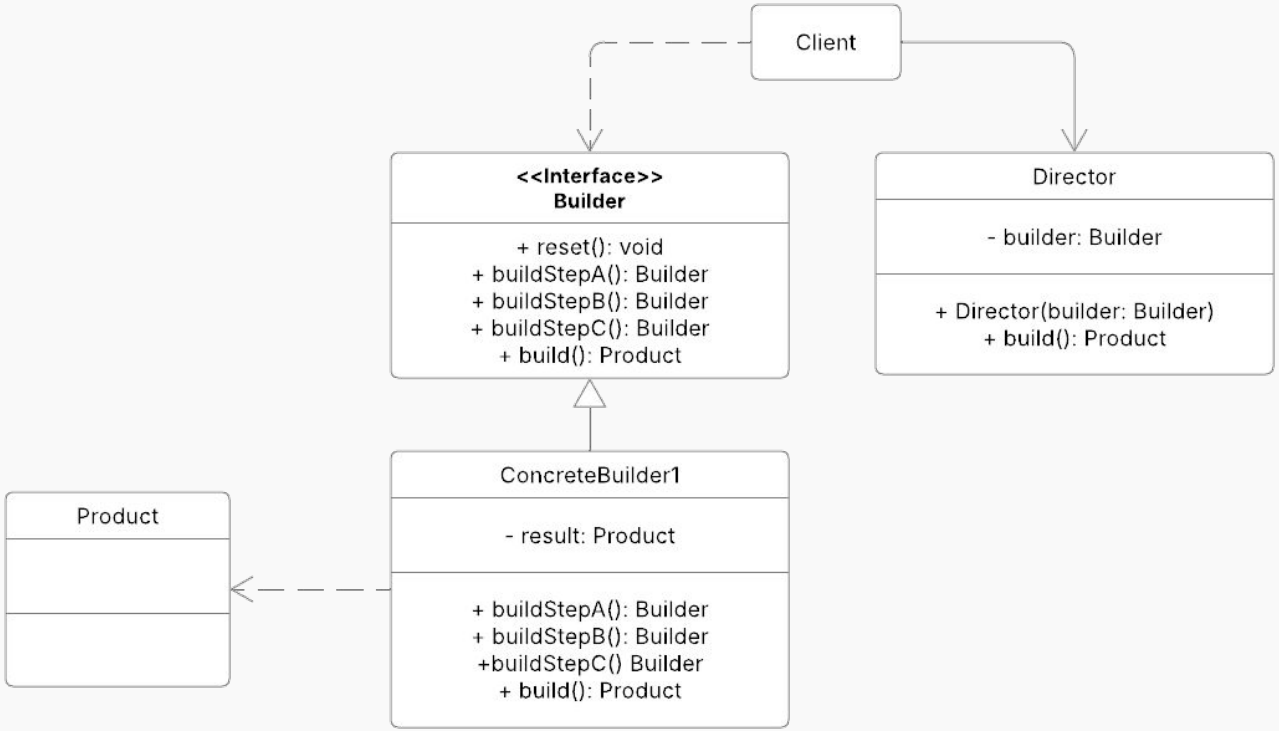
Creating a house

```
export class House {
  public constructor (
    private windows: number,
    private rooms: number,
    private doors: number,
    private hasGarage: boolean,
    private hasGarden: boolean,
    private hasStatues: boolean) {}
}
```

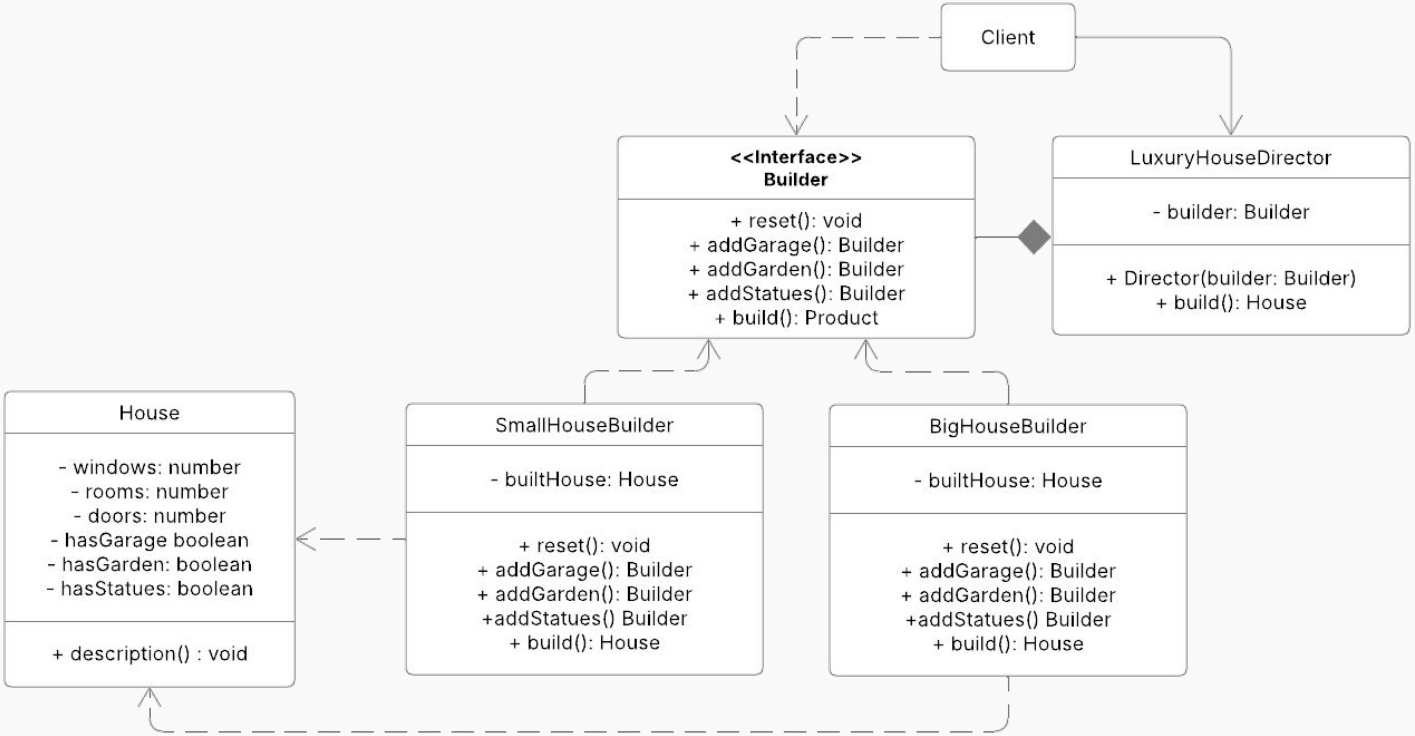
Large constructors are... complicated

```
const myBasicHouse = new House(4, 2, 4, false, false, false);
const myHouseWithGarage = new House(4, 2, 4, true, false, false);
const myLuxuryHouse = new House(4, 2, 4, true, true, true);
```

Class Diagram - Generic



Class Diagram - Specific



House builder interface

```
export interface Builder {
  reset(): void;
  builder(): House;
  addGarage(): Builder;
  addGarden(): Builder;
  addStatues(): Builder;
}
```

SmallHouseBuilder (1)

```
export class SmallHouseBuilder implements Builder {
  private hasGarden: boolean = false;
  private hasGarage: boolean = false;
  private hasStatues: boolean = false;
  private static readonly windows = 4;
  private static readonly rooms = 2;
  private static readonly doors = 4;

  public addGarage(): SmallHouseBuilder {
    this.hasGarage = true;
    return this;
  }
}
```

SmallHouseBuilder (2)

```
export class SmallHouseBuilder implements Builder {
  // ...
  public addGarden(): SmallHouseBuilder {
    this.hasGarden = true;
    return this;
  }

  public addStatues(): SmallHouseBuider {
    this.hasStatues = true;
    return this;
  }

  public build(): House {
    return new House(
      // All parameters ...
    );
  }
}
```

LuxuryHouseDirector

```
export class LuxuryHouseBuilder {
  public constructor(private builder: Builder) {}

  public build(): House {
    this.builder.addGarage().addGarden().addStatues();
    return this.builder.build();
  }
}
```

Usage example

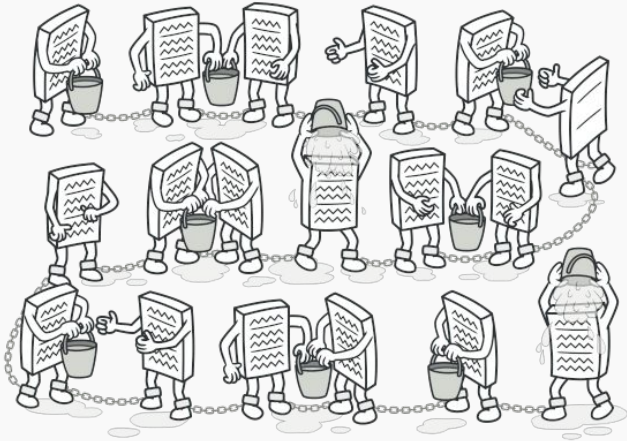
```
const smallNormalHouse = new SmallHouseBuilder().build();
const bigGardenHouse = new BigHouseBuilder().addGarden.build();
const smallLuxuryDirector = new LuxuryHouseDirector(new SmallHouseBuilder());
const smallLuxuryHouse = smallLuxuryDirector.build();
```

Builder - Creational

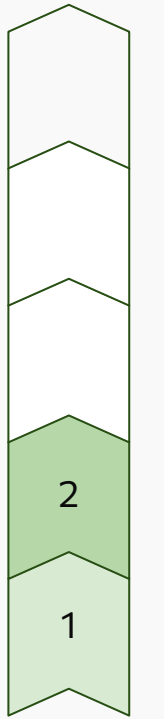
Advantages	Disadvantages
— Allows constructing objects step by step.	— Overall complexity increases, because of several new classes
— Allows reusing the same construction code	
— Enforces Single Responsibility Principle	

Chain of responsibility - Behavioral

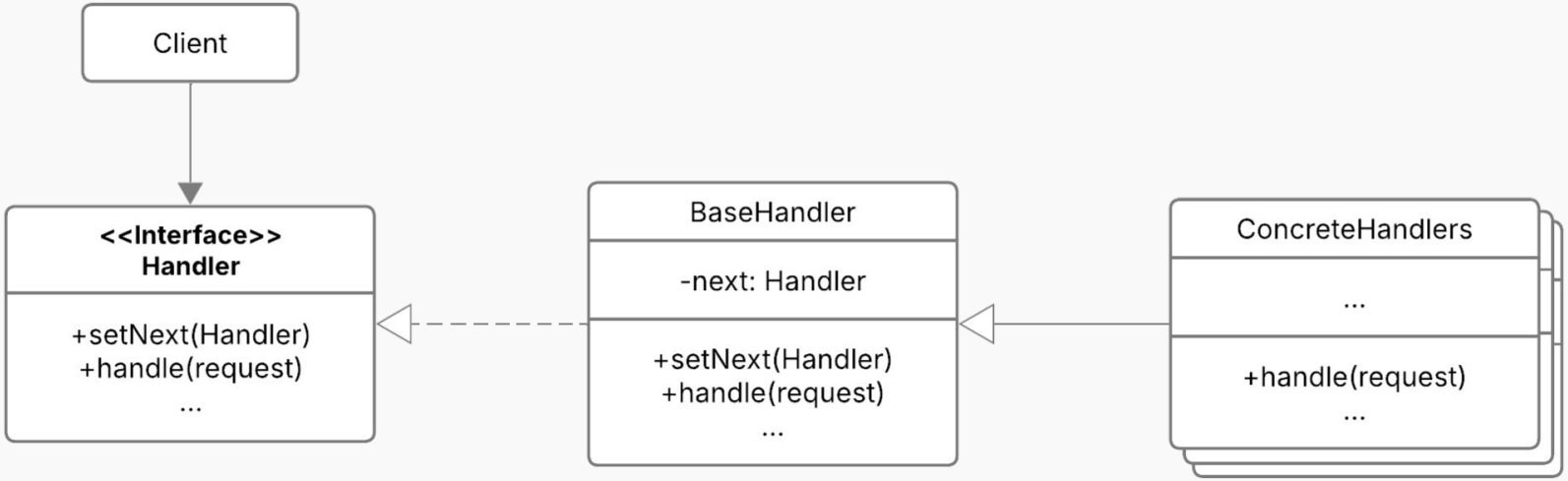
- Allows multiple objects to handle a request without specifying the receiver explicitly.
- It uses a chain of handler objects, where each handler decides to process the request or pass it to the next handler.
- Provides flexibility in handling requests but can lead to unclear flow control.



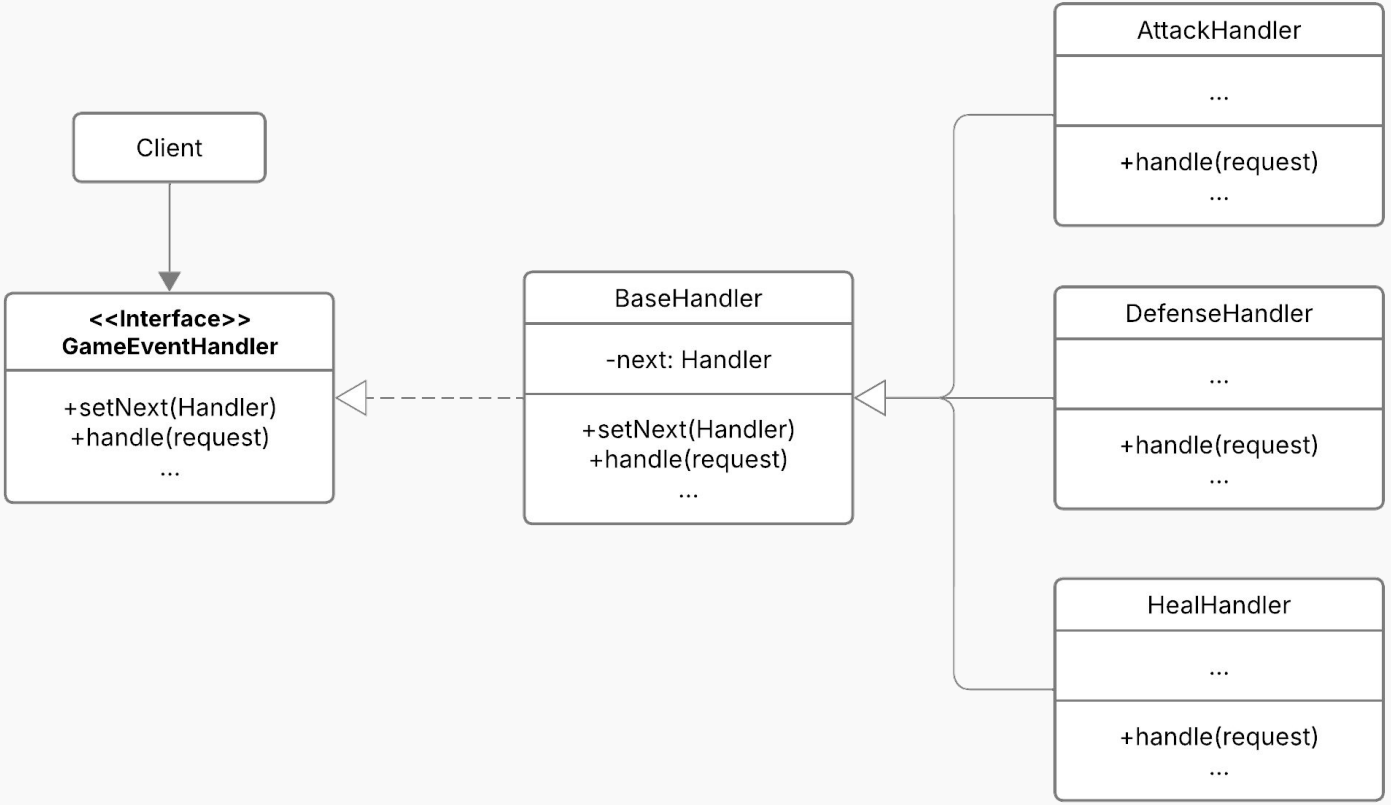
(Refactoring.Guru, 2025)



Class diagram - Generic



Class diagram - Example



GameEventHandler interface

```
interface GameEventHandler {
  setNextHandler(handler: GameEventHandler): GameEventHandler;
  handle(event: string): void;
}
```

Creating the base handler

```
abstract class BaseHandler implements GameEventHandler {
  protected nextHandler: GameEventHandler | null = null;

  setNextHandler(handler: GameEventHandler): GameEventHandler {
    this.nextHandler = handler;
    return handler;
  }

  handle(event: string): void {
    if (this.nextHandler) {
      this.nextHandler.handle(event);
    } else {
      console.log(`No handler found for event: ${event}`);
    }
  }
}
```

Attack handler

```
class AttackHandler extends BaseHandler {
  handle(event: string): void {
    if (event === "attack") {
      console.log("Player attacks the enemy!");
    } else {
      super.handle(event);
    }
  }
}
```

Defense handler

```
class DefenseHandler extends BaseHandler {
  handle(event: string): void {
    if (event === "defend") {
      console.log("Player blocks the attack!");
    } else {
      super.handle(event);
    }
  }
}
```

Heal handler

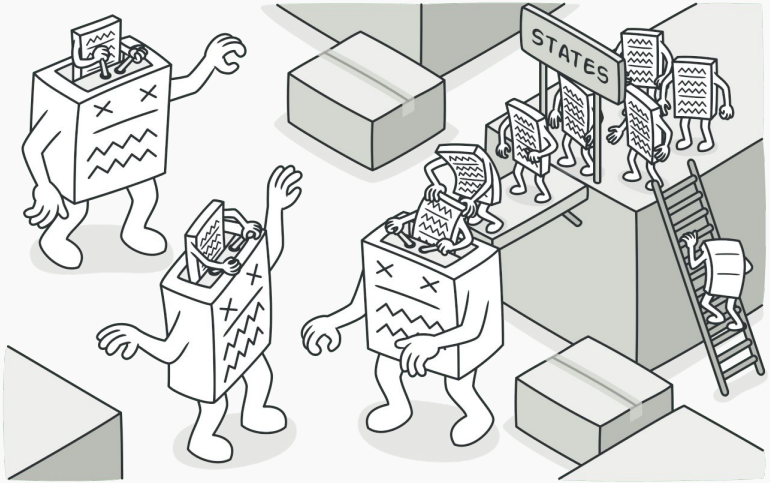
```
class HealHandler extends BaseHandler {
  handle(event: string): void {
    if (event === "heal") {
      console.log("Player uses a potion to restore health!");
    } else {
      super.handle(event);
    }
  }
}
```

Chain of responsibility - Behavioral

Advantages	Disadvantages
— Decoupling of the sender, the message and the receiver	— Control flow is not guaranteed
— Dynamic request handling	— Added complexity
— Flexibility	— Makes debugging difficult
— Single responsibility	— Could worsen performance

State - Behavioural

- One State machine object which changes behaviour
- Many State objects which alter behaviour
- More elegant than a chain of if or switch statements



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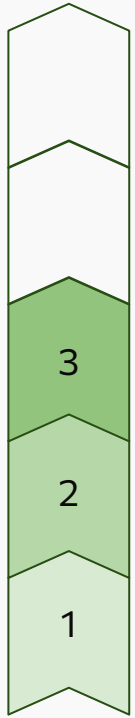
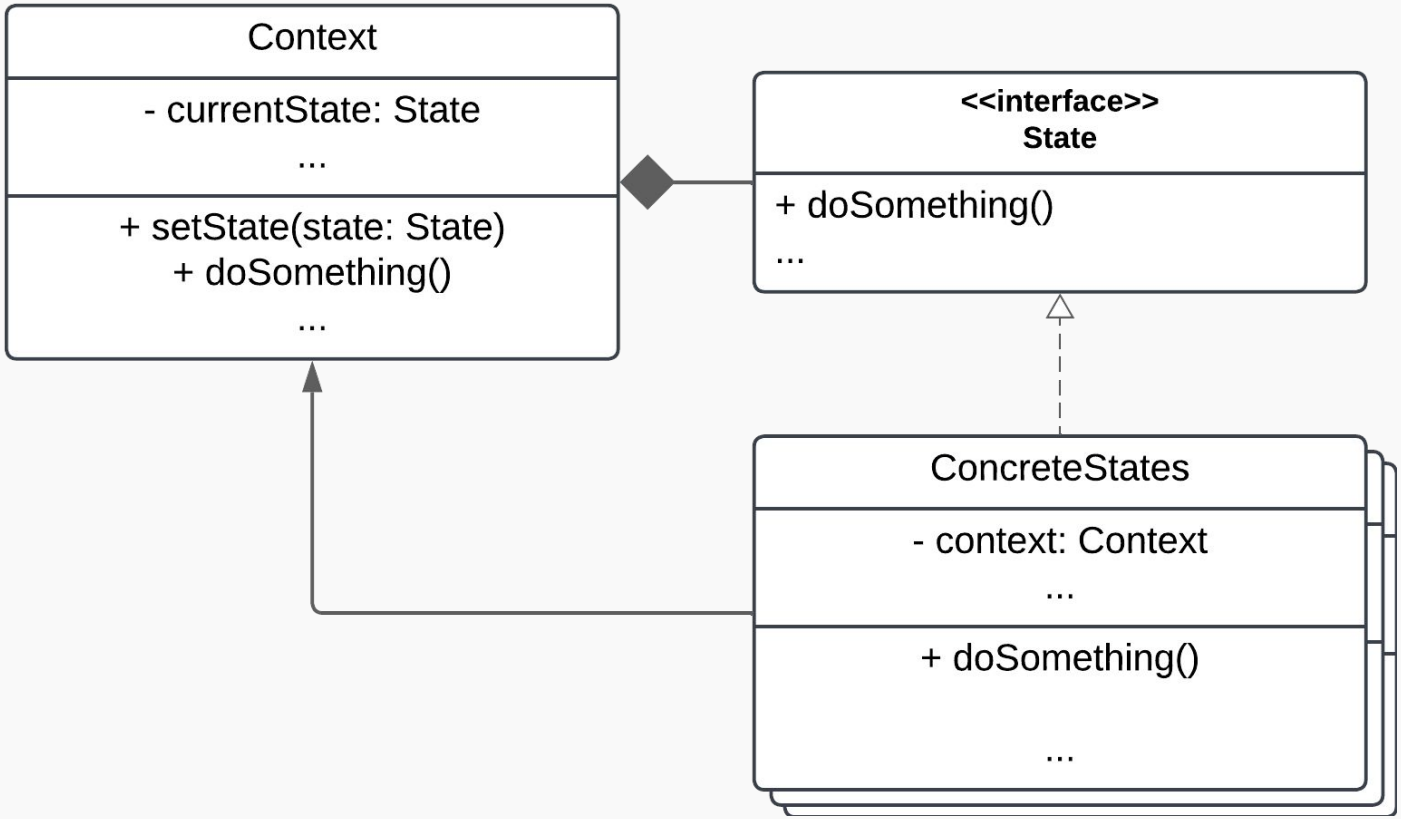
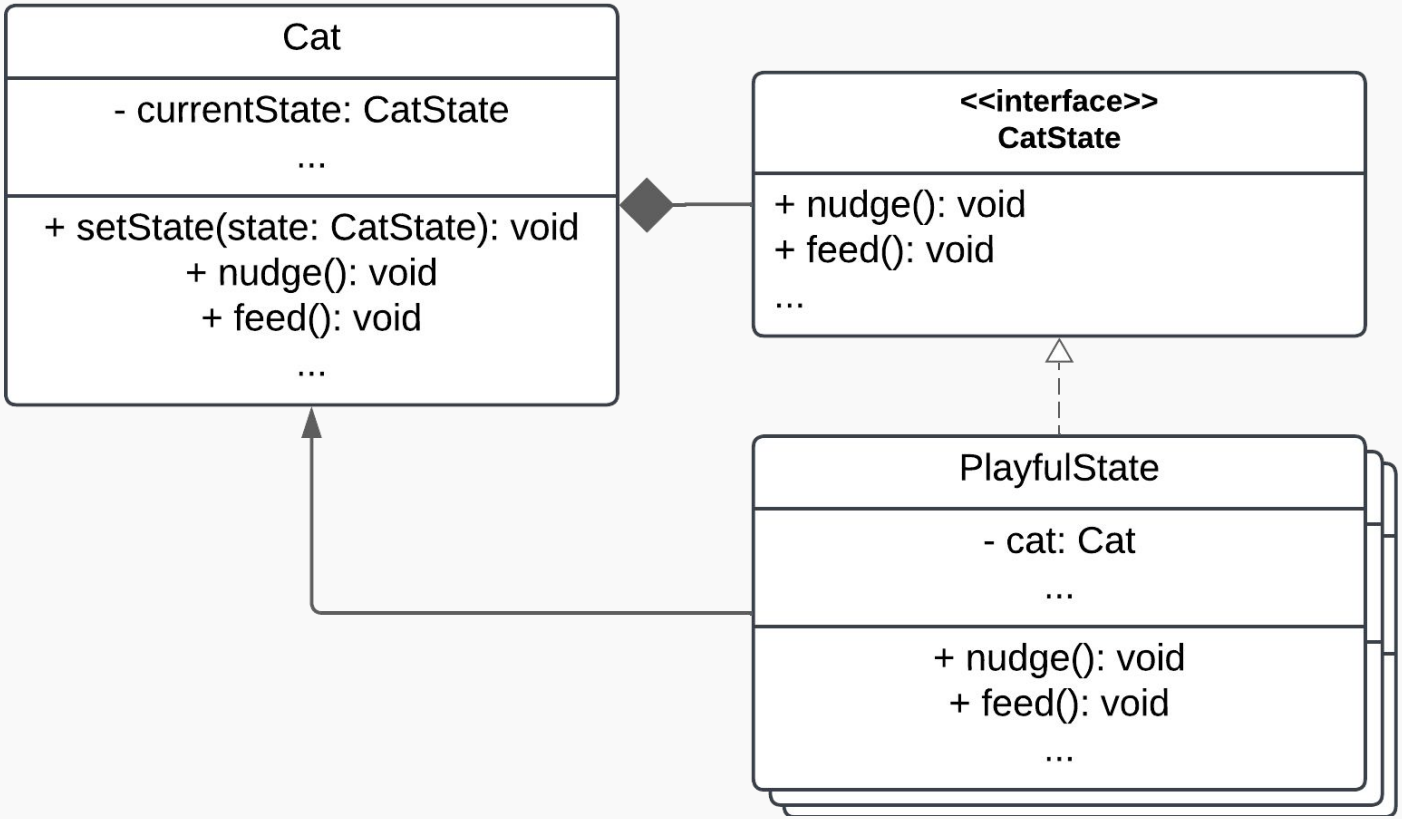


Frequency of use

Class diagram - Generic



Class diagram - Example



Context - Cat

```
export class Cat {
  private sleepingState: CatState;
  private hungryState: CatState;
  private playfulState: CatState;
  private currentState: CatState;

  constructor() {
    this.sleepingState = new SleepingState(this);
    this.hungryState = new HungryState(this);
    this.playfulState = new PlayfulState(this);
    // Cat starts off sleeping
    this.currentState = this.sleepingState;
  }
   ...
}
```

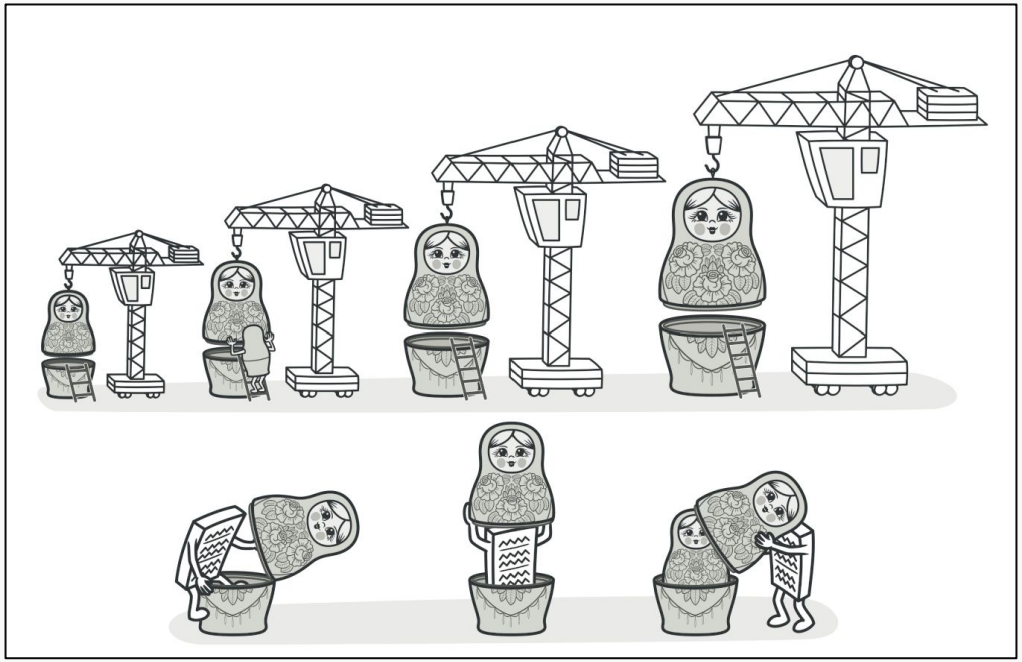
State - PlayfulState

```
export class PlayfulState implements CatState {
  private cat: Cat;

  constructor(cat: Cat) {
    this.cat = cat;
  }

  nudge(): void {
    console.log("The cat gets startled and decides it's time to sleep.");
    this.cat.setState(this.cat.getSleepingState());
  }
}
```

State - Behavioural

Advantages	Disadvantages
— Enforces Single responsibility principle	— Increases general code complexity
— Enforces Open/Closed principle	— Difficult to unit test
— Easy unit testing	— Complex initial setup
— Readable code	— Can be memory-heavy

Decorator - Structural



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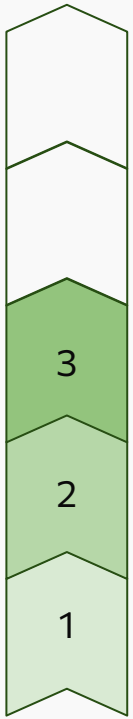


The Enemy interface

```
export interface Enemy {
  name(): string();
  receivedDamage(damage: number): number;
}
```

Creating a concrete Enemy

```
export class ZombieEnemy implements Enemy {
  public name(): string {
    return 'Zombie';
  }
  public receiveDamage(damage: number): number {
    return damage;
  }
}
```

Creating a Zombie with Helmet

```
export class ZombieWithHelmet implements Enemy {
  public name(): string {
    return 'Zombie';
  }
  public receiveDamage(damage: number): number {
    return damage - 5;
  }
}
```

Creating a Zombie with Chestplate

```
export class ZombieWithChestplate implements Enemy {
  public name(): string {
    return 'Zombie';
  }
  public receiveDamage(damage: number): number {
    return damage - 10;
  }
}
```

Creating a Zombie with... both?

```
export class ZombieWithHelmetAndChestplate implements Enemy {
  public name(): string {
    return 'Zombie';
  }
  public receiveDamage(damage: number): number {
    return damage - 5 - 10;
  }
}
```

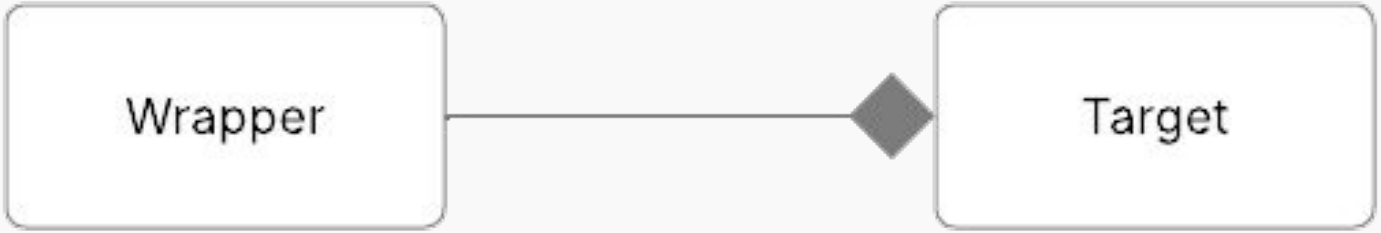
This is horrible

```
export class ZombieWithChestplate implements Enemy {
  public name(): string {
    return 'Zombie';
  }
  public receiveDamage(damage: number): number {
    return damage - 5;
  }
}
```

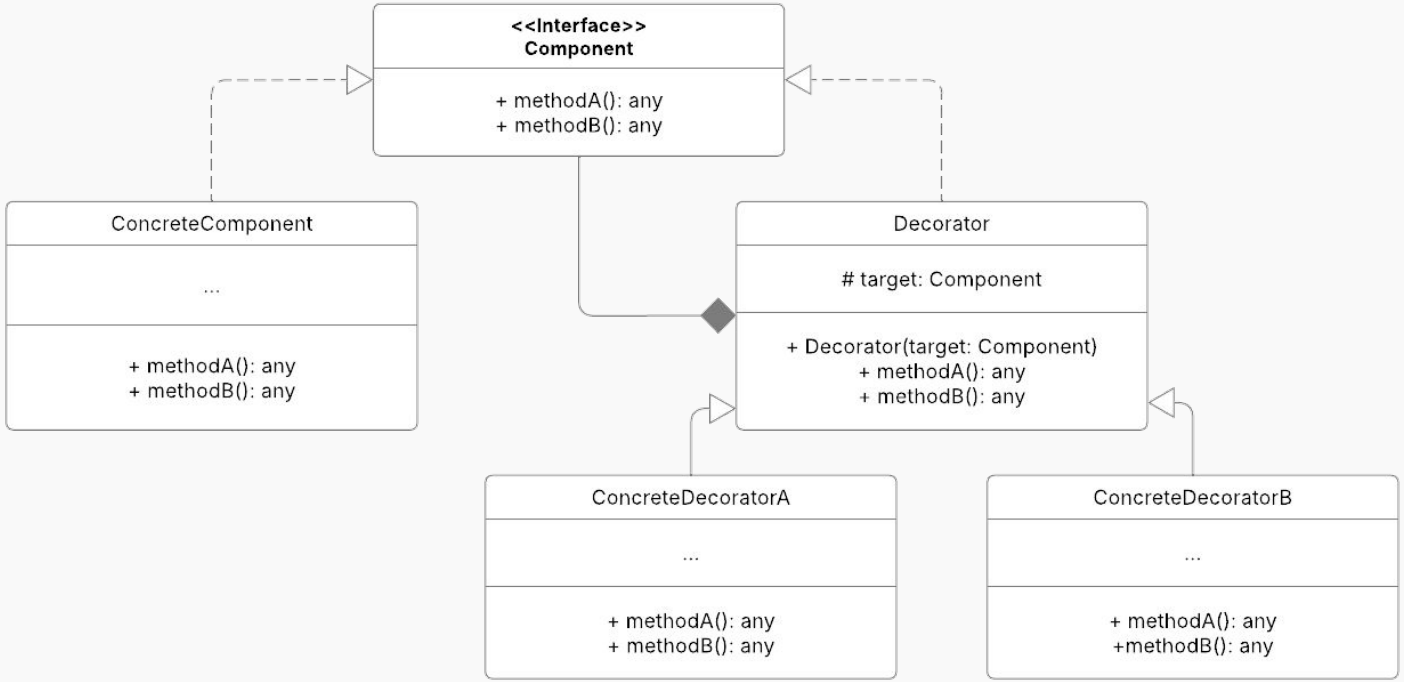
```
export class ZombieWithHelmet implements Enemy {
  public name(): string {
    return 'Zombie';
  }
  public receiveDamage(damage: number): number {
    return damage - 5;
  }
}
```

```
export class ZombieWithHelmetAndChestplate implements Enemy {
  public name(): string {
    return 'Zombie';
  }
  public receiveDamage(damage: number): number {
    return damage - 5 - 10;
  }
}
```

Wrapper ~= Decorator



Class Diagram - Generic



Creating the abstract decorator

```
export class EnemyDecorator implements Enemy {
  protected enemy: Enemy;
  public constructor(enemy: Enemy) {
    this.enemy = enemy;
  }
  public name(): string {
    return this.enemy.name();
  }
  public abstract receiveDamage(damage: number): number;
}
```

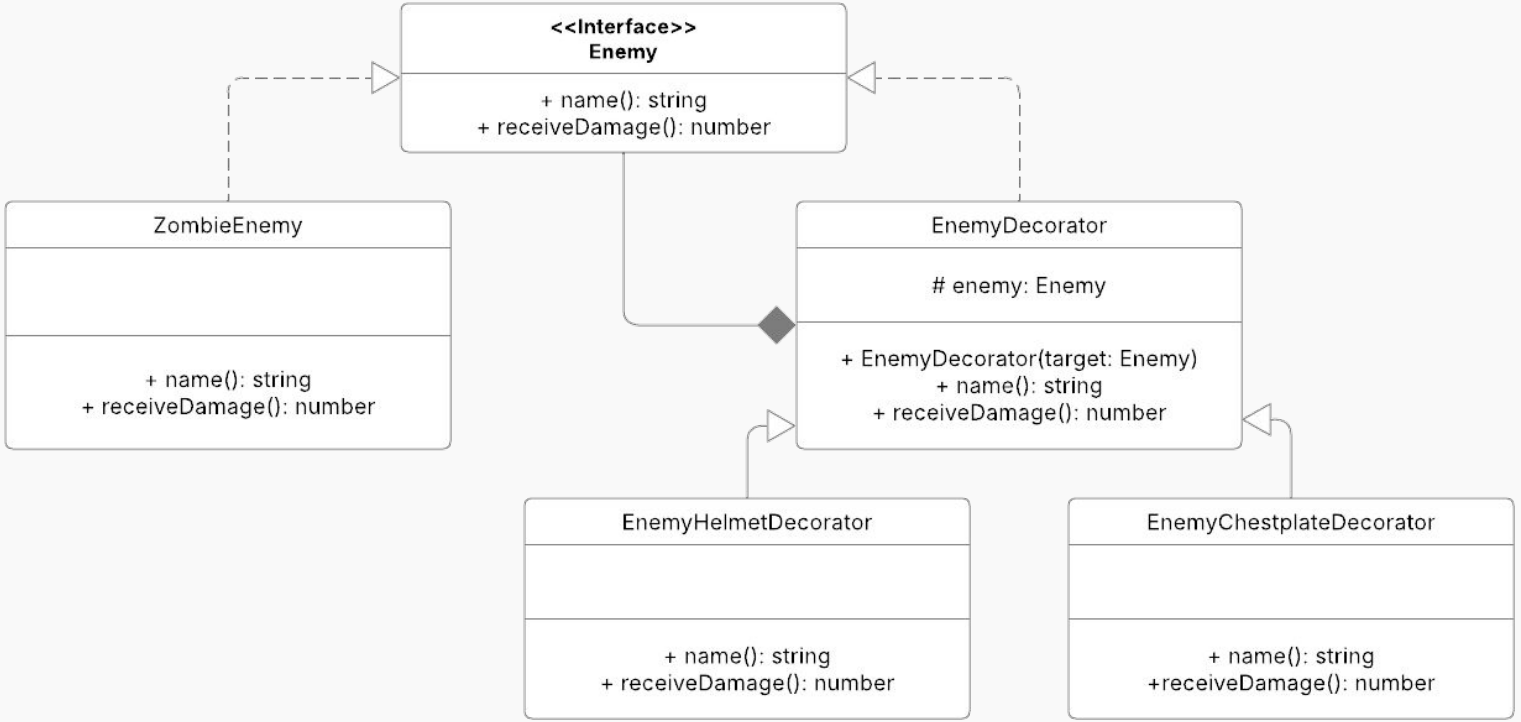
Creating the Helmet decorator

```
export class EnemyHelmetDecorator extends EnemyDecorator {
  public receiveDamage(damage: number) {
    return this.enemy.receiveDamage(damage) - 5;
  }
}
```

Creating the Chestplate decorator

```
export class EnemyChestplateDecorator extends EnemyDecorator {
  public receiveDamage(damage: number) {
    return this.enemy.receiveDamage(damage) - 10;
  }
}
```

Class Diagram - Example



Usage example (1)

```
let zombie = new ZombieEnemy();
console.log(zombie.receiveDamage(50)); // 50
let zombie = new EnemyWithHelmet(zombie);
console.log(zombie.name()); // Zombie
console.log(zombie.receiveDamage(50)); // 50 - 5 = 45
```

Usage example (2)

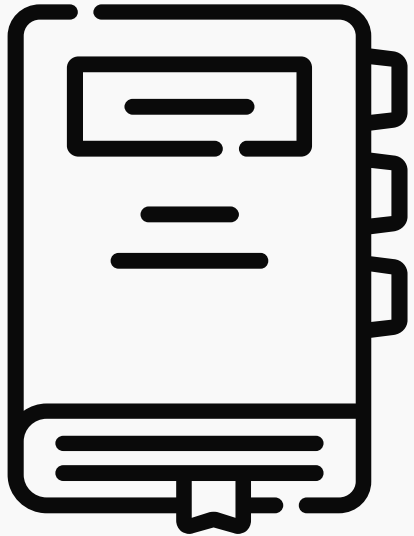
```
let zombie = new ZombieEnemy();
let zombie = new EnemyWithHelmet(zombie);
console.log(zombie.receiveDamage(50)) // 50 - 10 = 40
let zombie = new EnemyWithChestplate(zombie);
console.log(zombie.name()); // Zombie
console.log(zombie.receiveDamage(50)); // 50 - 5 - 10 = 35
```

Decorator - Structural

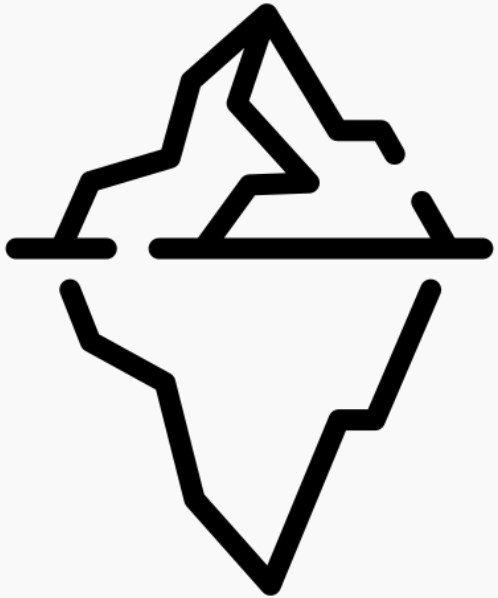
Advantages	Disadvantages
— Enforces Single responsibility principle	— Hard to un-do wrapping
— You can extend behavior without new subclasses	— Behavior depends on decorators order
— Combine several behaviors easily	— Initial code might look ugly

04

Conclusion



This is just the tip of the iceberg



- Observer
- Factory
- Abstract factory
- Strategy
- Template

...

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Thanks!

Do you have any questions?

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