AMSS Lecture 3: Design Patterns (I)

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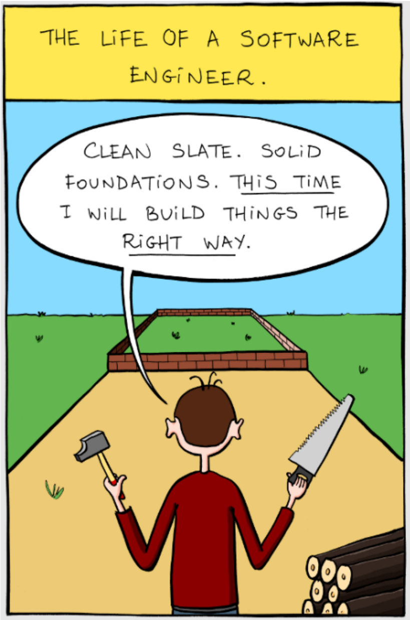
Agenda

1. What are Design Patterns?
2. Classification of Patterns
3. **Iterator Pattern**
4. **Builder Pattern**
5. **Singleton Pattern**
6. Wrap-up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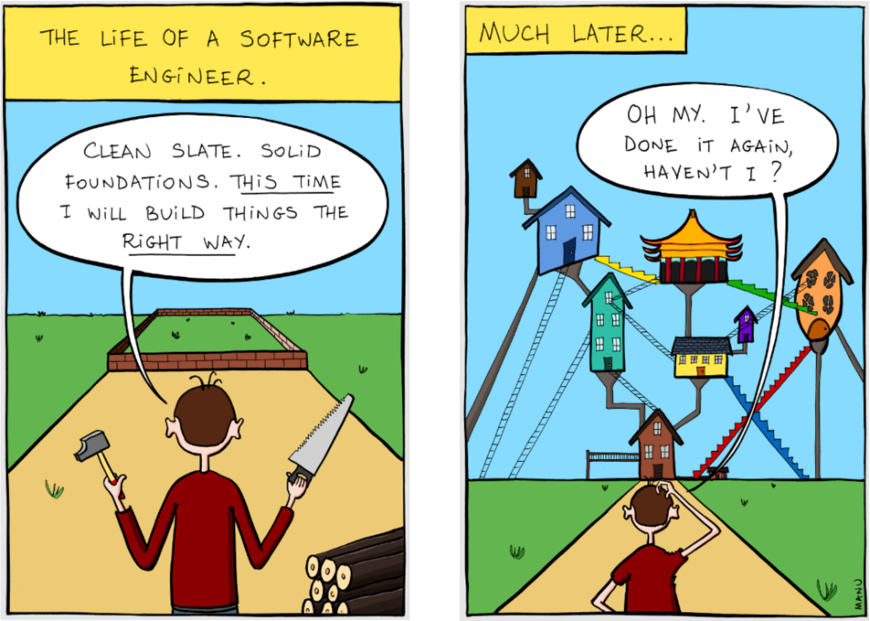

THE LIFE OF A SOFTWARE ENGINEER.
CLEAN SLATE. SOLID FOUNDATIONS. THIS TIME I WILL BUILD THINGS THE RIGHT WAY.
MUCH LATER...
OH MY. I'VE DONE IT AGAIN, HAVEN'T I ?
MANU

What Are Design Patterns?

Definition

Reusable solutions to common software design problems.

Origin

Popularized by the “Gang of Four” (Gamma, Helm, Johnson, Vlissides, 1994).

Purpose

- Provide shared vocabulary
- Improve code maintainability
- Promote reusability and clarity

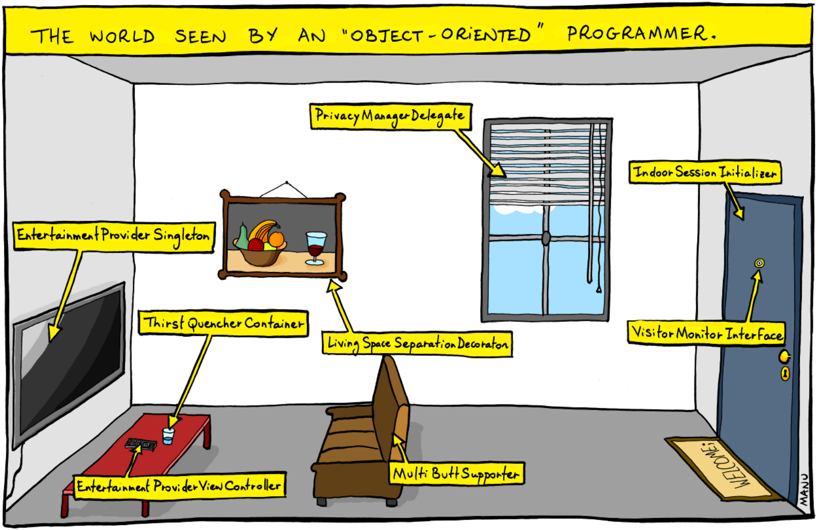
Example

Instead of reinventing how to traverse a collection, we apply the **Iterator** pattern.

Pattern Classification

Design patterns are typically grouped into three main categories:

Category	Description	Example Patterns
Creational	How objects are created	Singleton, Builder, Factory Method
Structural	How classes and objects are composed	Adapter, Bridge, Decorator
Behavioral	How objects interact and communicate	Iterator, Observer, State


THE WORLD SEEN BY AN "OBJECT-ORIENTED" PROGRAMMER.
Privacy Manager Delegate
Indoor Session Initializer
Entertainment Provider Singleton
Thirst Quencher Container
Living Space Separation Decorator
Visitor Monitor Interface
Multi Butt Supporter
Entertainment Provider View Controller
WELCOME!
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Iterator Pattern

Type

Behavioral pattern

Intent

Provide a way to access elements of a collection sequentially without exposing its internal structure.

Problem Solved

How to traverse a collection (e.g., list, tree, array) without knowing its implementation?

Solution

Define an `Iterator` interface with methods like `hasNext()` and `next()`.

Iterator Pattern code example

Source file

```
// Step 1: Create the Iterator interface
interface Iterator {
    boolean hasNext();
    Object next();
}

// Step 2: Create the Container interface
interface Container {
    Iterator getIterator();
}

// Step 3: Create a concrete class implementing Container
class NameRepository implements Container {
    private String[] names = {"Alice", "Bob", "Charlie", "I

    @Override
    public Iterator getIterator() {
```

Iterator Pattern Exercise

Exercise

Modify 3 lines in the example above to make the iterator a reverse iterator.

Question

> *How does this custom Iterator differ from Java's built-in `java.util.Iterator`, and when might you still implement your own?*

Builder Pattern

Type

Creational pattern

Intent

Separate the construction of a complex object from its representation, so the same construction process can create different representations.

Problem Solved

How can we construct complex objects step by step while keeping the construction logic separate from the representation?

Solution

Use a *Builder* class to encapsulate object creation in multiple steps.

Builder Pattern (concrete example)

Design a Computer class that represents a configurable computer system. The goal is to let users "build" a computer step-by-step, choosing which components to include. A computer may include:

- CPU (e.g., "Intel i9", "AMD Ryzen 7")
- GPU (e.g., "NVIDIA RTX 4090", "AMD Radeon RX 7800")
- RAM (in GB)
- Storage (in GB)

You should be able to build objects fluently, like this:

```
Computer gamingPC = new Computer.Builder()
        .setCPU("Intel i9")
        .setGPU("NVIDIA RTX 4090")
        .setRAM(32)
        .setStorage(2000)
        .build();
System.out.println(gamingPC);
```

Builder Pattern (concrete example solution)

Source file

```
// Product class
class Computer {
    private String CPU;
    private String GPU;
    private int RAM;
    private int storage;

    // Private constructor - use Builder instead
    private Computer(Builder builder) {
        this.CPU = builder.CPU;
        this.GPU = builder.GPU;
        this.RAM = builder.RAM;
        this.storage = builder.storage;
    }

    @Override
    public String toString() {
```

Bulder Pattern exercise

Design a Pizza class that represents a customizable pizza order, using the Builder Pattern. Your pizza should have:

- A size (e.g., Small, Medium, Large)
- A crust type (e.g., Thin, Thick, Stuffed)
- A list of toppings (e.g., Cheese, Pepperoni, Mushrooms)
- A flag for extra cheese

The goal is to make object creation flexible and readable, like this:

```java
Pizza pizza = new Pizza.Builder()
        .setSize("Large")
        .setCrust("Stuffed")
        .addTopping("Pepperoni")
        .addTopping("Mushrooms")
        .setExtraCheese(true)
        .build();
System.out.println(pizza);
```

Singleton Pattern

Type

Creational pattern

Intent

Ensure a class has only one instance, and provide a global point of access to it.

Problem Solved

How can we make sure there is exactly one instance of a class used throughout a system?

Solution

- Make the constructor private
- Store a static instance reference
- Provide a static accessor

Singleton Pattern (concrete example)

Implement a `DatabaseConnection` class that simulates a single, shared connection to a database.

The program should ensure that:

- Only one instance of the connection is ever created.
- Any part of the program that requests a connection gets the same instance.

Example use

```
DatabaseConnection conn1 = DatabaseConnection.getInstance()
DatabaseConnection conn2 = DatabaseConnection.getInstance()

conn1.query("SELECT * FROM users");

System.out.println(conn1 == conn2); // should print true
```

Singleton Pattern (concrete example solution)

Source file

```
// Singleton class
class DatabaseConnection {
    // Step 1: Create a private static instance of the clas
    private static DatabaseConnection instance;

    // Step 2: Make the constructor private to prevent ins
    private DatabaseConnection() {
        System.out.println("Connecting to the database...")
    }

    // Step 3: Provide a public static method to get the s
    public static DatabaseConnection getInstance() {
        if (instance == null) {
            instance = new DatabaseConnection();
        }
        return instance;
    }
```

Singleton Pattern exercise

Implement a `Logger` for a simple application. Only one instance of this class should ever exist, and all parts of the program should share it.

Example use

```java
Logger logger1 = Logger.getInstance();
Logger logger2 = Logger.getInstance();

logger1.log("Starting the app...");
logger2.log("App is running.");

// Both should refer to the same instance
System.out.println(logger1 == logger2); // true
```

Expected output

```
Logger initialized.
[LOG]: Starting the app...
[LOG]: App is running.
true
```