Announcements

- Project 1 Progress Report due tonight
- REST assignment due next Thursday
- Quiz 2 Statistics
  - Mean: 13.49/15; Std Dev: 1.5

Georgia Tech

CS3300 Introduction to Software Engineering

Lecture 08: Tools of the Trade #4

Spring, Spring Boot

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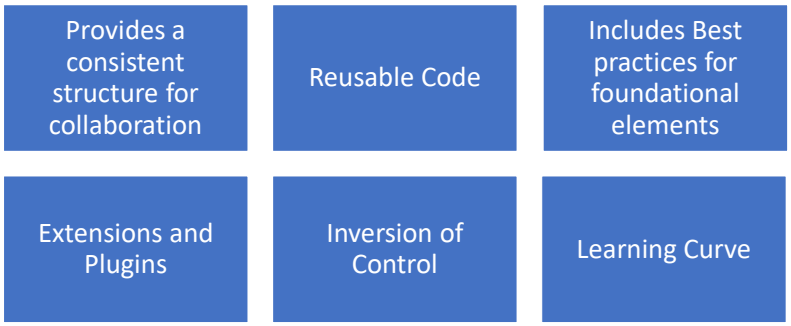
Contents

- Java Frameworks
- Spring
  - Advantages, IoC, Dependency Injection
- Spring Boot
  - Starter Projects, Auto Configurations
- Demo

Frameworks

- Framework is a predefined set of tools, libraries, best practices, and conventions that helps developers create applications more efficiently and effectively.
- Provides a foundation on which developers can build programs for a specific platform.

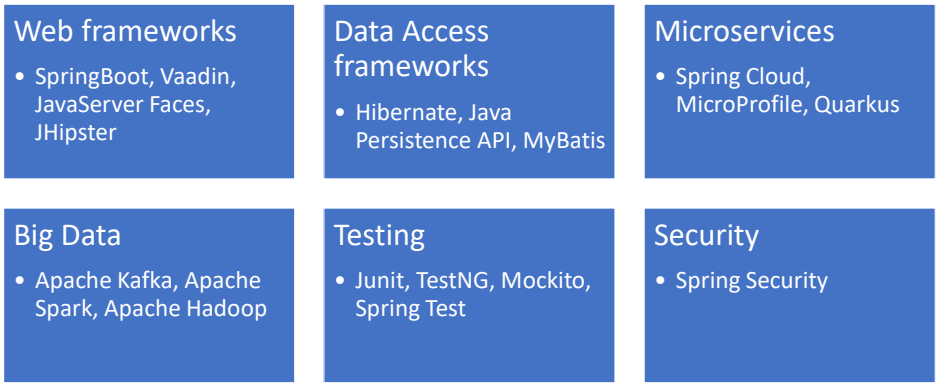


1.Structure & Conventions: Frameworks provide a consistent structure. This structure can make it easier for developers to collaborate on projects because everyone is familiar with the established project organization.
2.Reusable Code: They often come with a lot of built-in functionalities that can be reused, reducing the need to build everything from scratch. This significantly speeds up the development process.
3.Best Practices: Frameworks embody best practices for specific tasks (like data handling, error management or user authentication). This means developers can focus on the application's unique functionality rather than the intricacies of foundational elements.
4.Extensions & Plugins: Many frameworks can be extended with plugins or modules, allowing developers to add specific features without altering the core system.
5.Abstraction: Frameworks typically offer higher-level abstractions for common tasks (like database operations, routing, or UI components). This abstraction layer shields developers from some of the complexities of these operations.
6."Inversion of Control": In a traditional library, the custom code that calls the library is in control. But in a framework, the control is inverted: the framework calls the custom code. This is sometimes referred to as the "Hollywood Principle" - "Don't call us; we'll call you."

7. **Learning Curve**: While frameworks can accelerate development, there's often a learning curve involved. Developers need to invest time in understanding how the framework operates, its conventions, and its quirks.

Java Frameworks

- Java framework is a body of reusable prewritten code acting as templates used by developers to create apps using the Java programming language



1.Web Frameworks:

1. **Spring Boot**: An extension of the Spring framework that simplifies the process of building production-ready applications. It provides conventions for setting up a project, so you can get up and running as quickly as possible.
2. **JavaServer Faces (JSF)**: A Java web application framework that simplifies the development of user interfaces for Java web applications.
3. **Vaadin**: Focuses on providing a rich user interface for web apps without requiring developers to write HTML, CSS, or JavaScript.
4. **JHipster**: A generator to create a Spring Boot + Angular/React web application.

2.Data Access Frameworks:

1. **Hibernate**: An Object-Relational Mapping (ORM) framework that lets you develop persistent classes using object-oriented concepts, without having to deal with the database specifics.
2. **JPA (Java Persistence API)**: A specification for object-relational mapping in Java. Hibernate is one of its implementations.
3. **MyBatis**: A SQL mapping framework that integrates with Spring and other platforms.

3. **Microservices:**
    1. **Spring Cloud**: Provides tools for developers to quickly build some of the common patterns in distributed systems (e.g., configuration management, service discovery).
    2. **MicroProfile**: A set of APIs for creating microservices in Java.
    3. **Quarkus**: A Kubernetes-native Java framework tailored for GraalVM and HotSpot, crafted for serverless, microservices, and fast boot times.

4.Reactive Programming:

1. **Spring WebFlux**: A reactive framework that is part of the Spring 5+ ecosystem.
2. **Vert.x**: A tool-kit for building reactive applications on the JVM.
3. **Reactor**: A reactive programming library for building non-blocking applications on the JVM.

5.RESTful Services:

1. **Jersey**: The JAX-RS reference implementation for building RESTful web services in Java.
2. **Spring REST**: Spring's way of building RESTful web services.

6.Big Data & Data Processing:

1. **Apache Kafka**: A distributed streaming platform.
2. **Apache Spark**: A fast, in-memory data processing engine with elegant and expressive development APIs.
3. **Apache Hadoop**: A framework for distributed processing of large data sets across clusters.

7.Testing:

1. **JUnit**: The most popular framework for unit testing Java applications.
2. **TestNG**: Another testing framework inspired by JUnit but introducing some new functionalities.
3. **Mockito**: A popular mocking framework for unit tests in Java.
4. **Spring Test**: Provides support for testing Spring components with JUnit.

8.Security:

1. **Spring Security**: A comprehensive security solution for Java applications, focusing on authentication and authorization.

9.WebSockets:

1. **Atmosphere**: A framework that supports WebSocket-based communication.
2. **Spring WebSocket**: Spring's module for handling WebSocket communication.

10.Task Scheduling & Background Processing:

•**Quartz Scheduler**: A richly featured, open-source job scheduling library.

•**Spring Batch**: A framework for batch processing.

11.Mobile Development:

•**Codename One**: Allows Java developers to write native mobile applications for all

devices.

12. GUI Development:

•**JavaFX**: Java's official GUI toolkit for developing desktop applications.

•**Swing**: The predecessor to JavaFX, but still used in many legacy applications.

13.Cloud & Deployment:

•**Docker**: While not exclusive to Java, Docker is used heavily in the Java world for containerizing applications.

•**Kubernetes**: Again, not exclusive to Java, but with the rise of microservices, Kubernetes is becoming a staple for orchestrating containers.

Framework *vs.* API

- Framework serves as a foundation for programming, while an API provides access to the elements supported by the framework.
- Framework includes an API
- Will also include code libraries, compiler and other programs needed for software development

Spring

- Most popular, powerful, lightweight and open-source application development framework used for Java Enterprise Edition (JEE). Other frameworks include Hibernate, JSF, Struts etc.
    - JEE is built upon Java SE (Standard Edition) . Provides functionalities like web application development, servlets etc.
    - JEE provides APIs for running large scale applications

Lightweight- less memory consumption

Advantages of Spring

- MVC architecture. Distinct division between models (data), controllers (application logic) and views(user interface).
- Framework of frameworks. Can easily integrate with other frameworks like Struts, Hibernate etc.
- Flexibility
- One stop-shop for all enterprise applications. But modular, allows you to pick which modules you need.
- Allows loose coupling among modules
- Easier to test
- Increases efficiency due to reduction in application development time

Hibernate: An Object-Relational Mapping (ORM) framework that allows developers to work with databases using Java objects, avoiding direct SQL usage.

Inversion of Control (IoC)

- Principle in software engineering which transfers the control of objects or portions of a program to a container or framework. Most often used in the context of object-oriented programming. The architecture helps in decoupling the execution of a task from its implementation.
- In Spring, objects configured in XML file and Spring container is responsible for creation and deletion of objects by parsing XML file.

XML files not part of source code. So u can change the configuration values anytime and that will get incorporated automatically.

In a traditional library, the custom code that calls the library is in control. But in a framework, the control is inverted: the framework calls the custom code. This is sometimes referred to as the "Hollywood Principle" - "Don't call us; we'll call you."

Inversion of Control (IoC)

Example of highly coupled classes

```
public class DataAccess
{
    public DataAccess()
    {
    }

    public string GetCustomerName(int id) {
        return "Dummy Customer Name"; // get it
    }
}
```

```
public class CustomerBusinessLogic
{
    DataAccess _dataAccess;

    public CustomerBusinessLogic()
    {
        _dataAccess = new DataAccess();
    }

    public string GetCustomerName(int id)
    {
        return _dataAccess.GetCustomerName(id);
    }
}
```

- *CustomerBusinessLogic* and *DataAccess* classes are tightly coupled. Changes in the *DataAccess* class will lead to changes in the *CustomerBusinessLogic* class. For example, if we add, remove or rename any method in the DataAccess class then we need to change the CustomerBusinessLogic class accordingly.
- The *CustomerBusinessLogic* class creates an object of the *DataAccess* class using the **new** keyword. There may be multiple classes which use the *DataAccess* class and create its objects. So, if you change the name of the class, then you need to find all the places in your source code where you created objects of *DataAccess* and make the changes throughout the code.
- Because the *CustomerBusinessLogic* class creates an object of the concrete *DataAccess* class, it cannot be tested independently (TDD). The DataAccess class cannot be replaced with a mock class.

Inversion of Control (IoC)

Using Factory pattern of the IoC principle => Loosely coupled design

```
public class CustomerBusinessLogic
{

    public CustomerBusinessLogic()
    {
    }

    public string GetCustomerName(int id)
    {
        DataAccess _dataAccess =  DataAccessFactory.GetDataAccessObj();

        return _dataAccess.GetCustomerName(id);
    }
}


   public class DataAccess
   {
       public DataAccess()
       {
       }

       public string GetCustomerName(int id) {
           return "Dummy Customer Name"; // get it
       }
   }
```

```
public class DataAccessFactory
{
    public static DataAccess GetDataAccessObj()
    {
        return new DataAccess();
    }
}
```

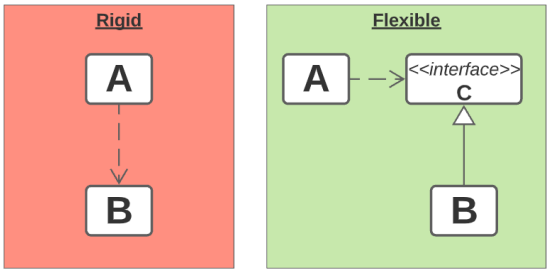
The *CustomerBusinessLogic* class uses the *DataAccessFactory*.*GetCustomerDataAccessObj*() method to get an object of the *DataAccess* class instead of creating it using the new keyword. Thus, we have inverted the control of creating an object of a dependent class from the *CustomerBusinessLogic* class to the *DataAccessFactory* class.

first step towards achieving fully loose coupled design.

Dependency Inversion Principle (DIP)

- A high-level module (depends on other modules) should not depend on low-level modules (*DataAccess* Class). Both should depend on abstraction.

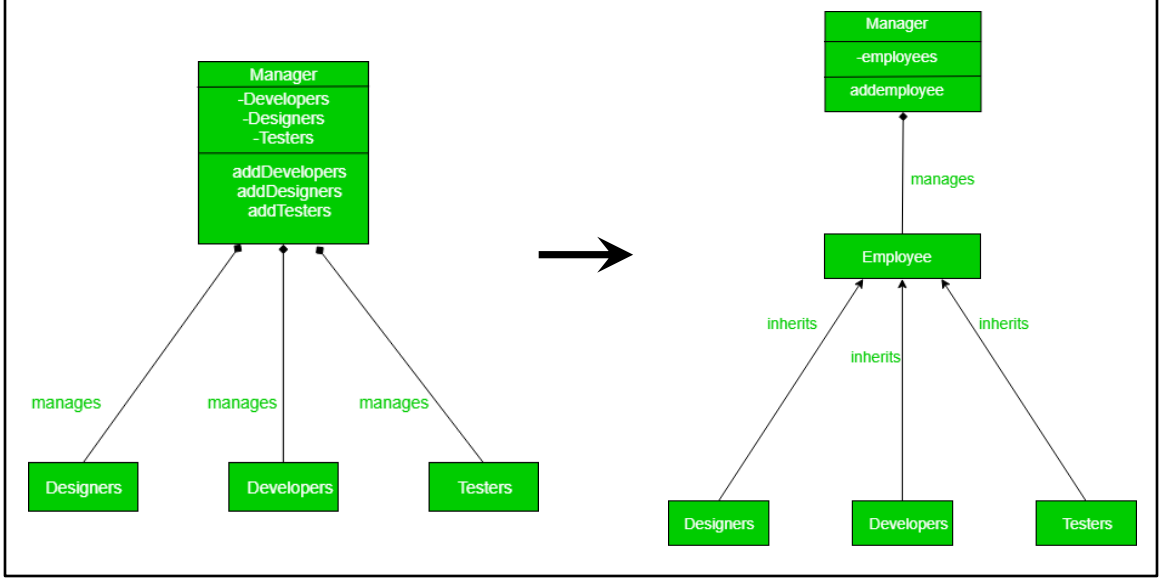
- Abstractions should not depend on details. Details should depend on abstractions



Abstraction in OOPS means to create an interface or an abstract class which is non-concrete. This means we cannot create an object of an interface or an abstract class.

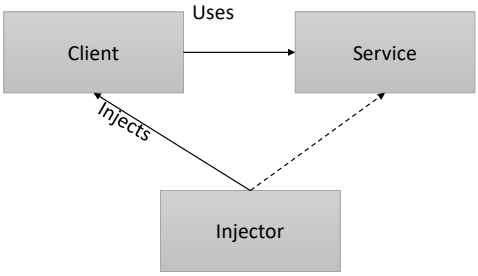
High-level modules typically contain the core logic of an application – the "business rules" or "use-cases". Low-level modules handle more specific, detailed operations, such as data access or interaction with certain tools or devices.
If high-level modules depend directly on low-level modules, then changes in the low-level modules might necessitate changes in the high-level ones. This leads to a tightly coupled system, making it harder to change, extend, or reuse components.
By depending on abstractions (like interfaces or abstract classes), we can decouple the high-level and low-level modules. Both modules rely on a stable contract (the abstraction) that doesn't frequently change, while the implementations behind the abstraction can be altered without affecting modules that rely on it.

Dependency Inversion Principle (DIP)



Dependency Injection (DI)

- Dependency Injection (DI) is a design pattern used to implement IoC. It allows the creation of dependent objects outside of a class and provides those objects to a class through different ways.
- Increases possibility to reuse classes and test independently of other classes while unit testing
- DI pattern includes 3 class types:



Injector class creates an object of service class, injects it to a client object. Hence, separates the responsibility of creating an object of service class out of the client class.

Benefits of using DI

- Helps in Unit testing.
- Boiler plate code is reduced, as initializing of dependencies is done by the injector component.
- Extending the application becomes easier.
- Helps to enable loose coupling, which is important in application programming.

Without DI example

```java
// Engine class
class Engine {
    public void start() {
        System.out.println("Engine started.");
    }
}
```

Problems with This Approach:

- **Tight Coupling**: The Car class is tightly coupled with the Engine class. If you want to change the engine type (e.g., to a DieselEngine), you must modify the Car class code.
- **Difficult to Test**: You cannot easily replace the Engine with a mock or stub for testing purposes.
- **Low Flexibility**: Every change in the Engine class or its behavior requires changes in the Car class.

```java
// Car class without Dependency Injection
class Car {
    private Engine engine;

    public Car() {
        // The Car class creates its own Engine instance
        this.engine = new Engine();
    }

    public void start() {
        engine.start();
        System.out.println("Car started.");
    }
}

// Usage
public class Main {
    public static void main(String[] args) {
        Car car = new Car(); // Car creates its own dependencies
        car.start();
    }
}
```

With DI example

```java
// Service class
class Engine {
    public void start() {
        System.out.println("Engine started.");
    }
}
```

```java
// Client class
class Car {
    private Engine engine; // Dependency

    // Constructor Injection: The Engine is injected via the constructor
    public Car(Engine engine) {
        this.engine = engine;
    }

    public void start() {
        engine.start(); // Using the injected dependency
        System.out.println("Car started.");
    }
}
```

```java
// Injector class
class CarInjector {
    public static Car getCar() {
        // Create the service instance (Engine)
        Engine engine = new Engine();

        // Inject the service into the client and return the client
        return new Car(engine);
    }
}
```

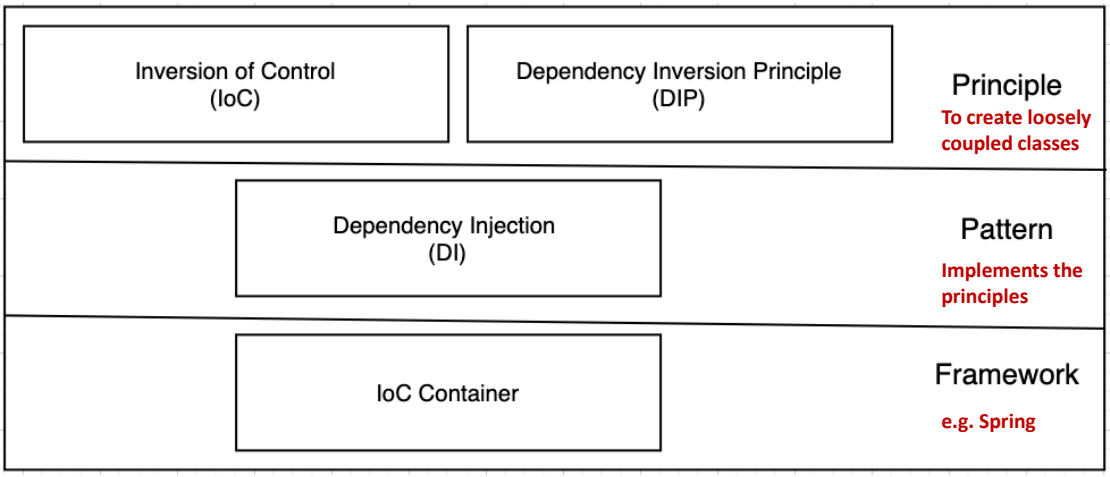
```java
public class Main {
    public static void main(String[] args) {
        // Use the injector to get the client with the service injected
        Car car = CarInjector.getCar();
        car.start();
    }
}
```

With DI example

Benefits of This Approach:

- **Loose Coupling**: The Car class is not tightly coupled to the Engine class. Any implementation of Engine (e.g., DieselEngine, ElectricEngine) can be injected.
- **Testability**: Easily test the Car class by injecting mock objects or stubs of the Engine.
- **Single Responsibility Principle**: The CarInjector class handles the creation and injection of dependencies, leaving the Car class focused on its core functionality.

IoC, DIP, DI


Inversion of Control
(IoC)
Dependency Inversion Principle
(DIP)
Principle
To create loosely coupled classes
Dependency Injection
(DI)
Pattern
Implements the principles
IoC Container
Framework
e.g. Spring

Spring Boot

- Spring Boot builds on top of Spring Framework, offering a streamlined approach to developing Spring applications with minimal boilerplate code, auto configuration, embedded servers, and other features. It means that you can **just run t**he application.
- Dependencies and configurations are managed by Spring Boot.
- Normally to run application, you need: hardware + OS + Server +Application file (.war for web applications). With Spring Boot: server embedded (Tomcat), executable files generated automatically.
- Features:
  - Provides with a starter project for the application along with auto configuration
  - Does not generate XML file but configuration can be modified (using YAML files, properties or XML)

Web application resource is a file used to distribute a collection of JAR-files, JavaServer Pages, Java Servlets, Java classes, XML files, tag libraries, static web pages (HTML and related files) and other resources that together constitute a web application.

DEMO TIME!!

- Create a simple web app using SpringBoot
- We needed Express in Node.js to establish the server. Spring Boot has Tomcat server embedded– very convenient

WHAT IF WE HAD TO CREATE THE SAME APP WITHOUT SPRING BOOT

- We have Spring framework
- Setup and manage all maven dependencies and versions in pom.xml manually – very extensive
- Define Web.xml file to configure web related front controller (if war)
- Define a Spring context XML file to define component scans
- Install Tomcat or configure Tomcat maven plugin
- Deploy and run application IN TOMCAT

Spring Boot Starter Projects

- Goal is to help you get a project up and running quickly
  - Web application: Spring-Boot-Starter-Web
  - REST API: Spring-Boot-Starter-Web
  - Talk to database using JPA- Spring-Boot-Starter-Data-JPA
  - Talk to database using JDBC- Spring-Boot-Starter-JDBC
  - Secure web application- Spring-Boot-Starter-Security

- Manage list of maven dependencies & versions for different apps:
  - Spring-Boot-Starter-Web: Frameworks needed by typical web applications. Spring-webmvc, spring-web, spring-boot-starter-tomcat, sprint-boot-starter-json

Spring Boot Auto Configuration

- Starter defines dependencies
- Auto configurations provides basic configuration to run application using frameworks defined in your maven dependencies
- Decided based on:
  - Which frameworks are in class path?
  - What is the existing configuration? (*Maven Dependencies* – *springframework.boot.autoconfigure* – classes that will be checked)
  - Type *logging.level.org.springframework=DEBUG* in *application.properties* to see what is being auto-configured.

Positive maches will be auto configured