# Computer System Design & Application

# 计算机系统设计与应用A

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# Lecture 12

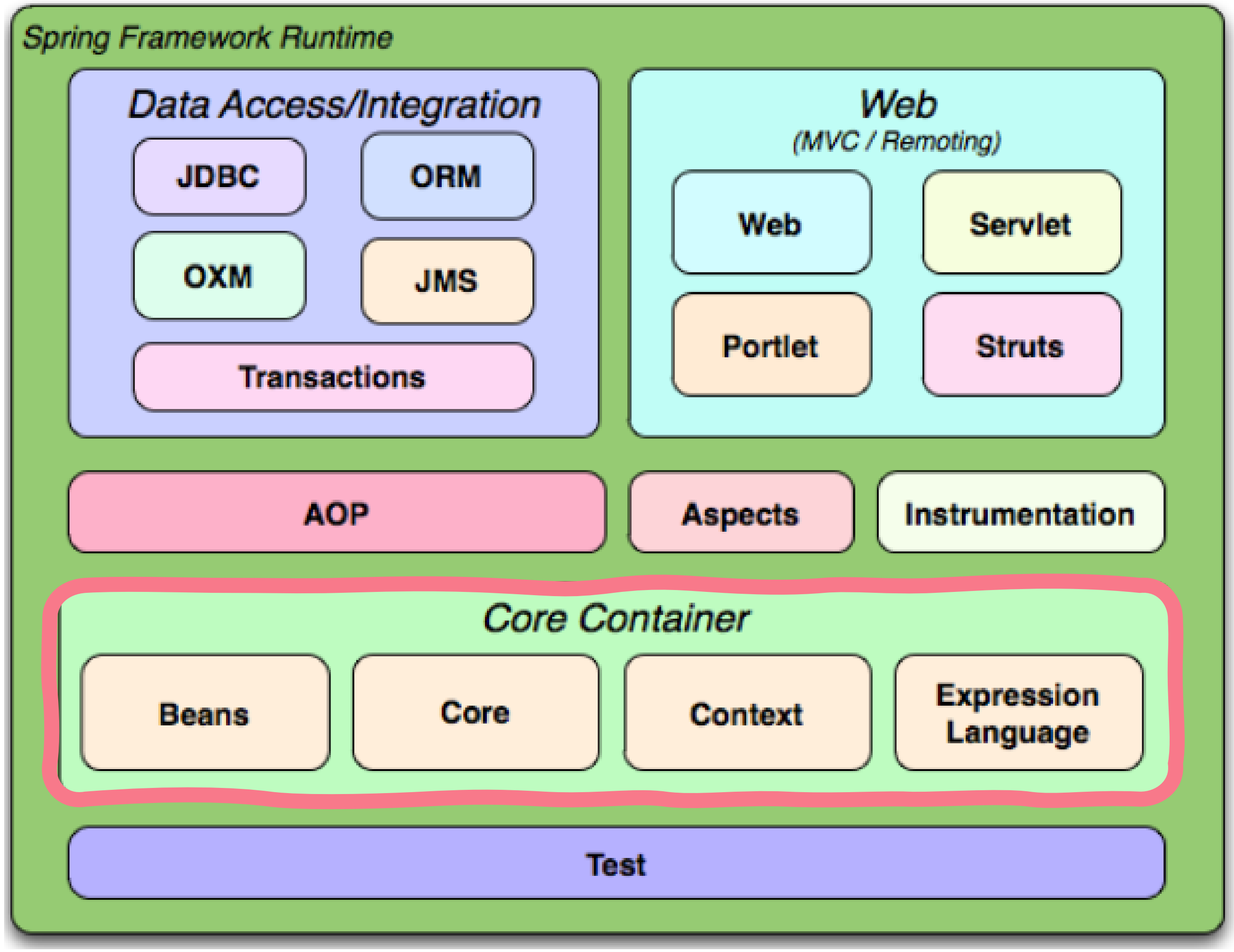
- The Spring Framework
  - IoC & Dependency Injection
  - Spring AOP
  - Spring MVC
- Spring Boot
  - Overview
  - Building a MVC web application
  - Building a RESTful web service

## The Spring Framework

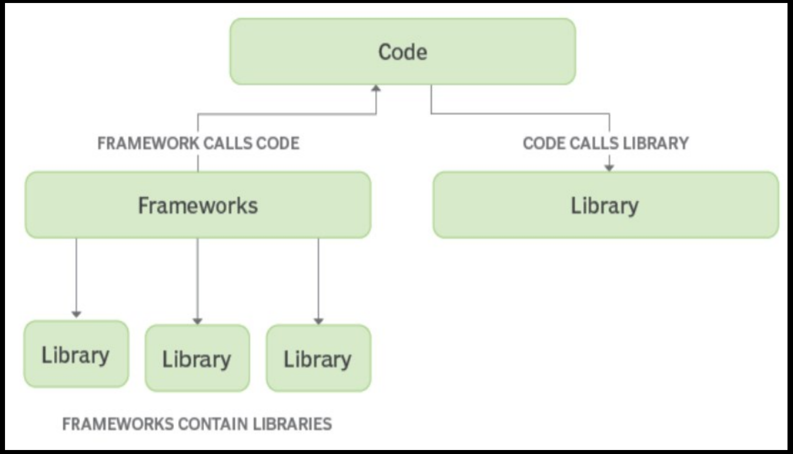
- The Spring Framework is an open-source, lightweight framework that enables developers to develop enterprise-class applications using Plain Old Java Object (POJO), instead of EJB
- It also offers tons of extensions that are used for building all sorts of large-scale applications on top of the Java EE platform

# The Spring Framework

- The Spring Framework consists of features organized into about 20 modules, as shown in the diagram
- Spring Core Container is required, other modules are optional
- Core Container is based on IoC and Dependency Injection



# Core Concepts in Spring

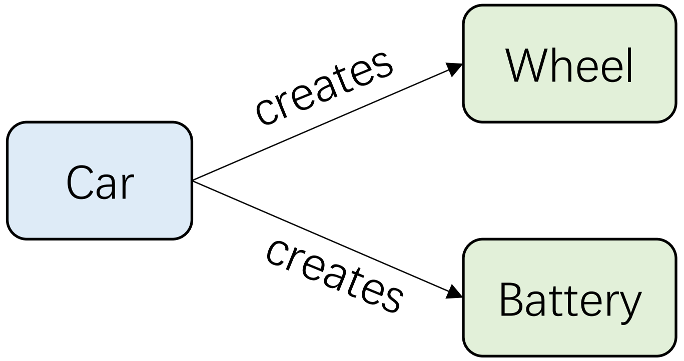


- Inversion of Control (IoC, 控制反转): a principle in SE which transfers the control of objects or portions of a program to a container or framework
- Traditionally, our custom code makes calls to a library; In contrast, IoC enables a framework to take control of the flow of a program and make calls to our custom code.
- To use a framework, you need to insert your behavior into various places in the framework either by subclassing or by plugging in your own classes. The framework's code then calls your code at these points.
- Dependency Injection (DI, 依赖注入): how IoC concept is implemented in Spring.

## Without Dependency Injection

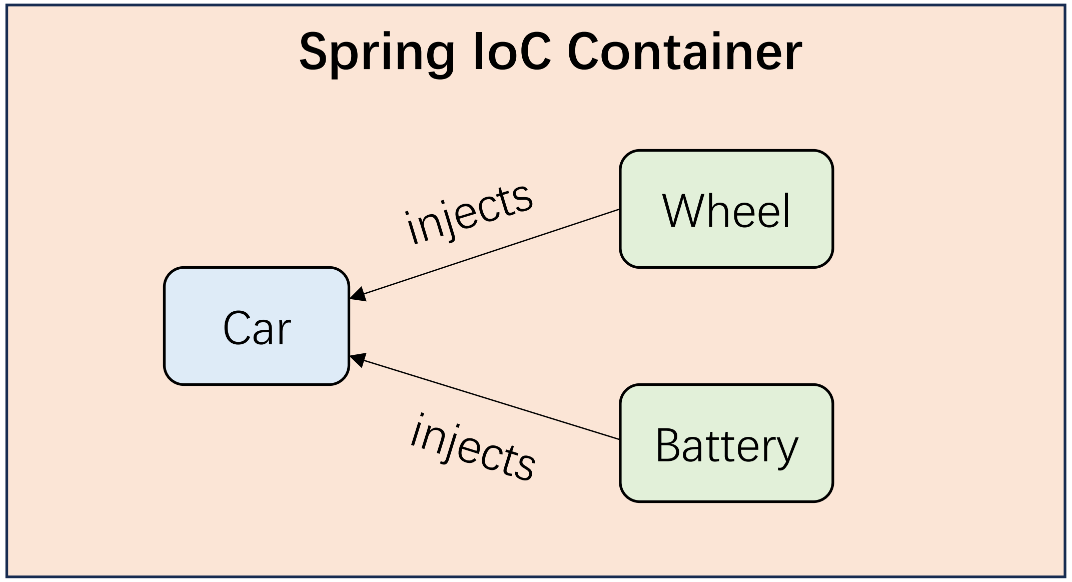
- The Car object is responsible for creating the dependent objects Wheel and Battery.
- The code is highly coupled (Car breaks if Battery's constructor changes)
- Hard to test (how to test Car?)

```
class Car {
    private Wheel wheel = new NepaliRubberWheel();
    private Battery battery = new ExcideBattery();

    // ......
}
```



# With Dependency Injection

- Spring IoC Container creates and injecting the dependencies (Wheel and Battery) at runtime.
- Injection can be done by setter injection or constructor injection.

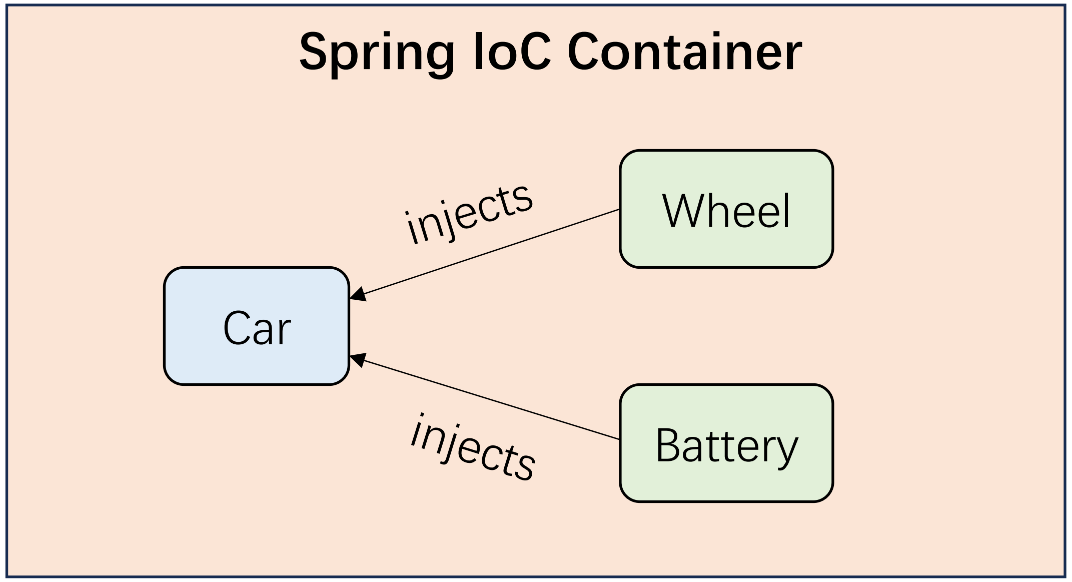


```java
class Car {
    private Wheel wheel;
    private Battery battery;

    public Car(Wheel wheel, Battery battery) {
        this.wheel = wheel;
        this.battery = battery;
    }

    void setWheel(Wheel wheel) {
        this.wheel = wheel;
    }

    void setBattery(Battery battery) {
        this.battery = battery;
    }
}
```

# With Dependency Injection

"Dependency Injection" is a 25-dollar term for a 5-cent concept. [...] Dependency injection means giving an object its instance variables.

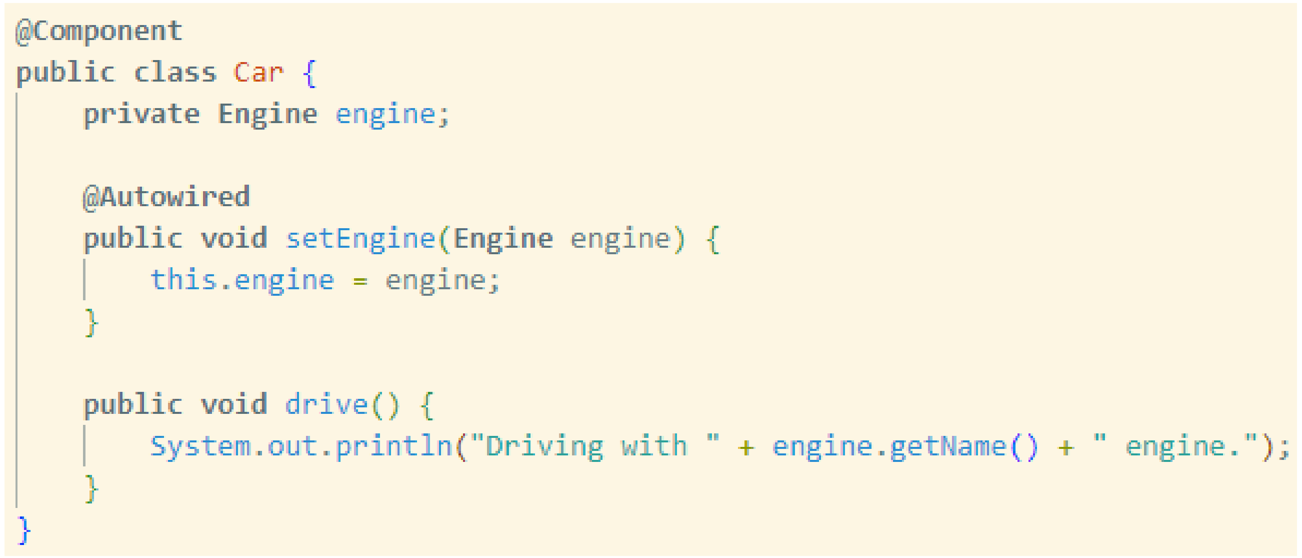
- James Shore



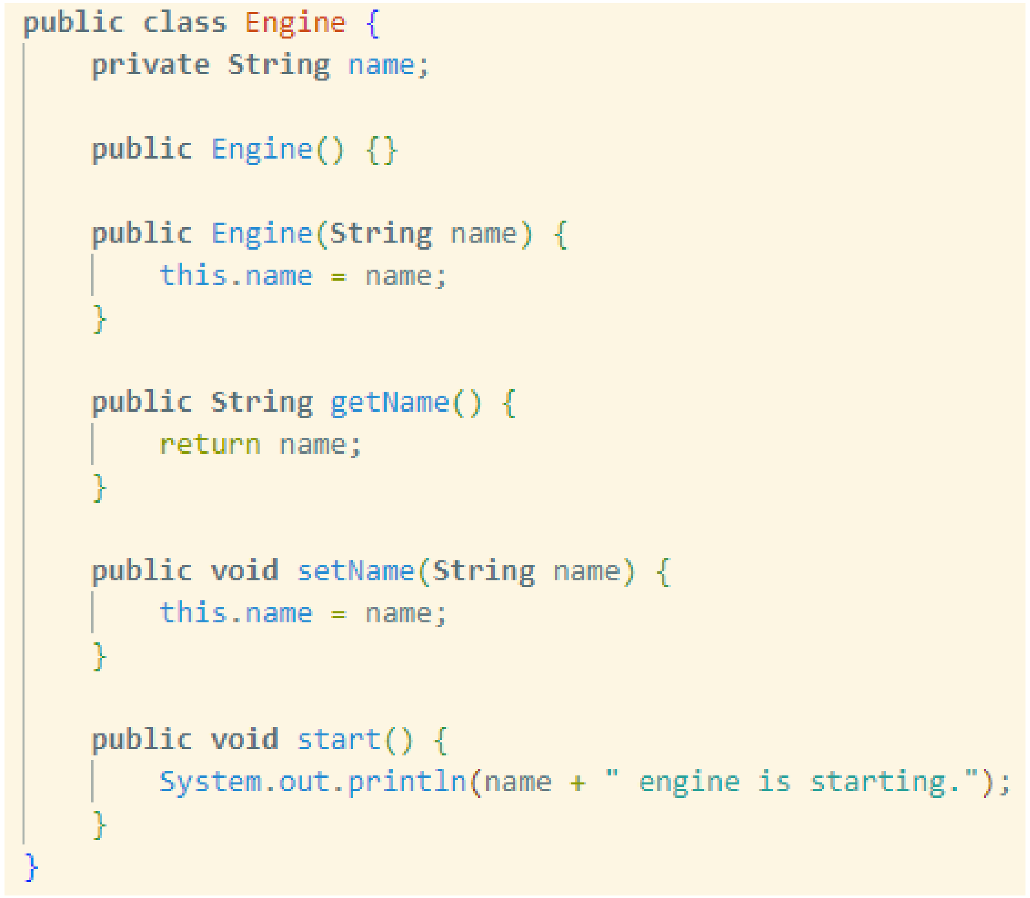
```
class Car {
    private Wheel wheel;
    private Battery battery;

    public Car(Wheel wheel, Battery battery) {
        this.wheel = wheel;
        this.battery = battery;
    }

    void setWheel(Wheel wheel) {
        this.wheel = wheel;
    }

    void setBattery(Battery battery) {
        this.battery = battery;
    }
}
```

**How does IoC container know which objects to create and their dependencies?**

## Annotations in Spring



```java
@Component
public class Car {
    private Engine engine;

    @Autowired
    public void setEngine(Engine engine) {
        this.engine = engine;
    }

    public void drive() {
        System.out.println("Driving with " + engine.getName() + " engine.");
    }
}
```

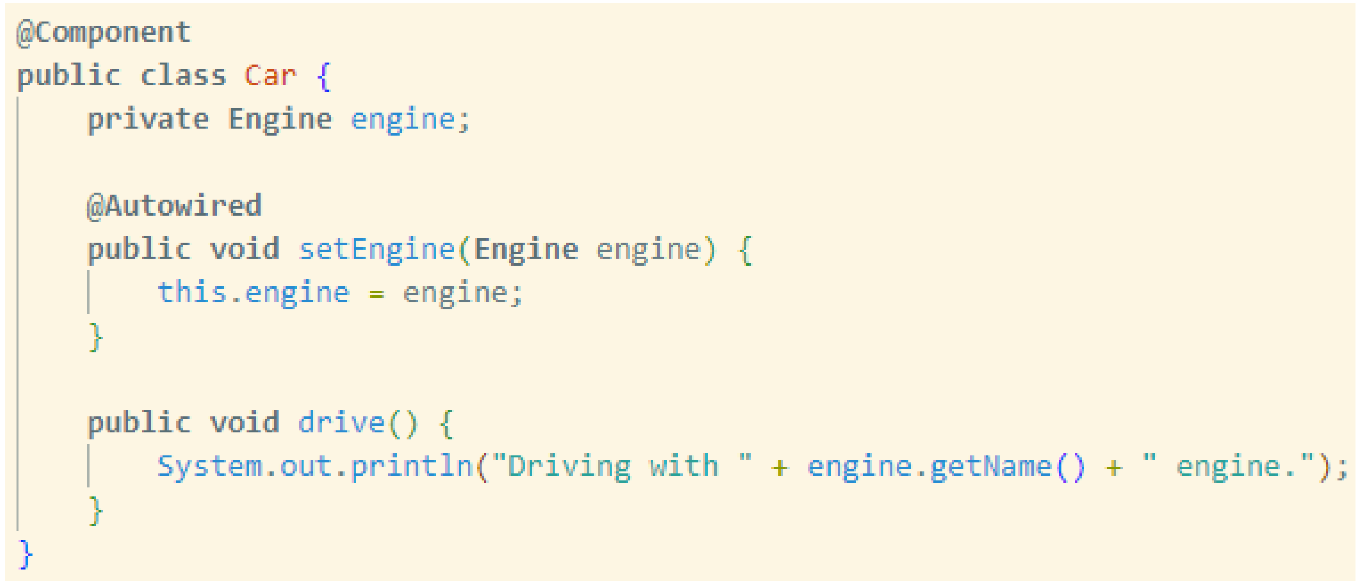


```java
public class Engine {
    private String name;

    public Engine() {}

    public Engine(String name) {
        this.name = name;
    }

    public String getName() {
        return name;
    }

    public void setName(String name) {
        this.name = name;
    }

    public void start() {
        System.out.println(name + " engine is starting.");
    }
}
```

- Business logics: `Car` and `Engine` (POJOs or Beans)
- `Car` depends on `Engine`

## @Component

- `@Component` is used for automatic bean detection
- Without having to write any code, Spring IoC container will:
    - Scan our application for classes annotated with `@Component`
    - Instantiate them and inject any specified dependencies into them
    - Inject them wherever needed



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public class Car {
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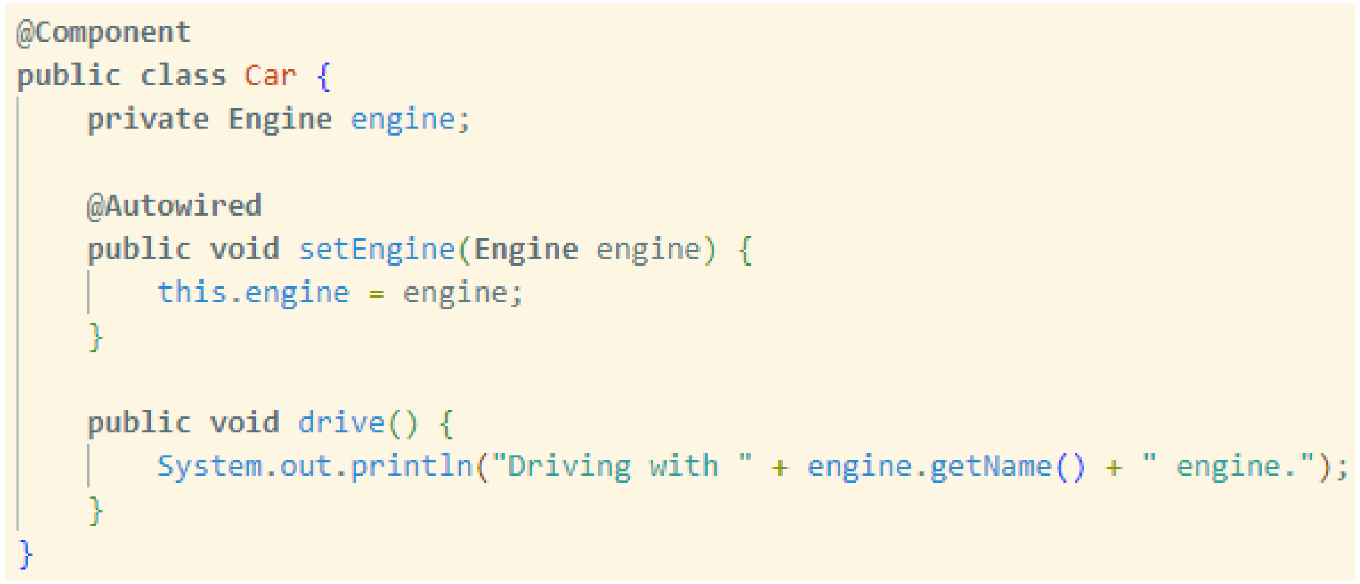
        this.engine = engine;
    }

    public void drive() {
        System.out.println("Driving with " + engine.getName() + " engine.");
    }
}
```

https://docs.spring.io/spring-framework/docs/3.2.x/spring-framework-reference/html/beans.html

# @Autowired

- `@Autowired` can be applied on setter methods and constructors.
- The `@Autowired` annotation injects object dependency implicitly.
- Autowiring allows the Spring container to automatically resolve dependencies between collaborating beans by inspecting the beans that have been configured



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    }
}
```
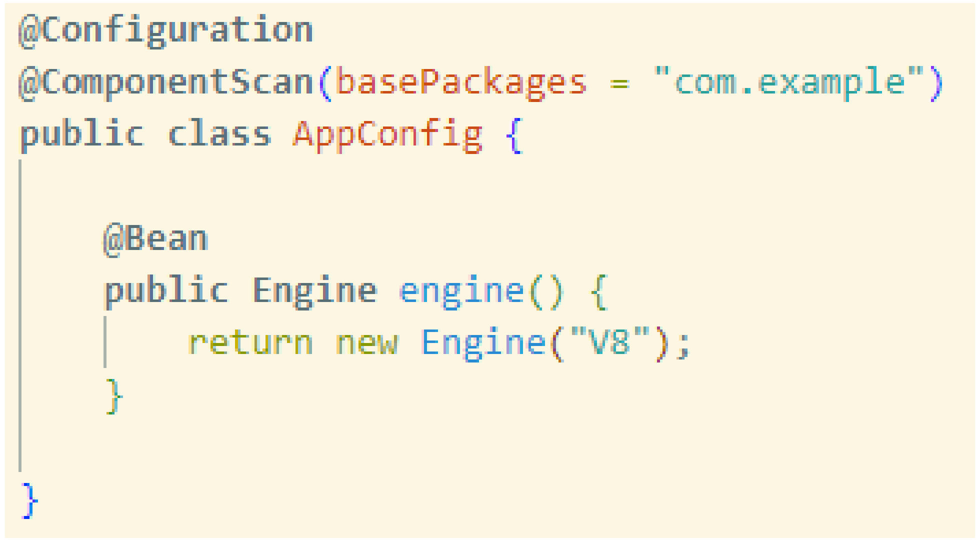

https://docs.spring.io/spring-framework/docs/3.2.x/spring-framework-reference/html/beans.html

## Configurations

- @Configuration
  - A Java class annotated with `@Configuration` is a configuration by itself
  - Classes with `@Configuration` define and instantiate beans
- @ComponentScan
  - We use the `@ComponentScan` annotation along with the `@Configuration` annotation to specify the packages that we want to be scanned

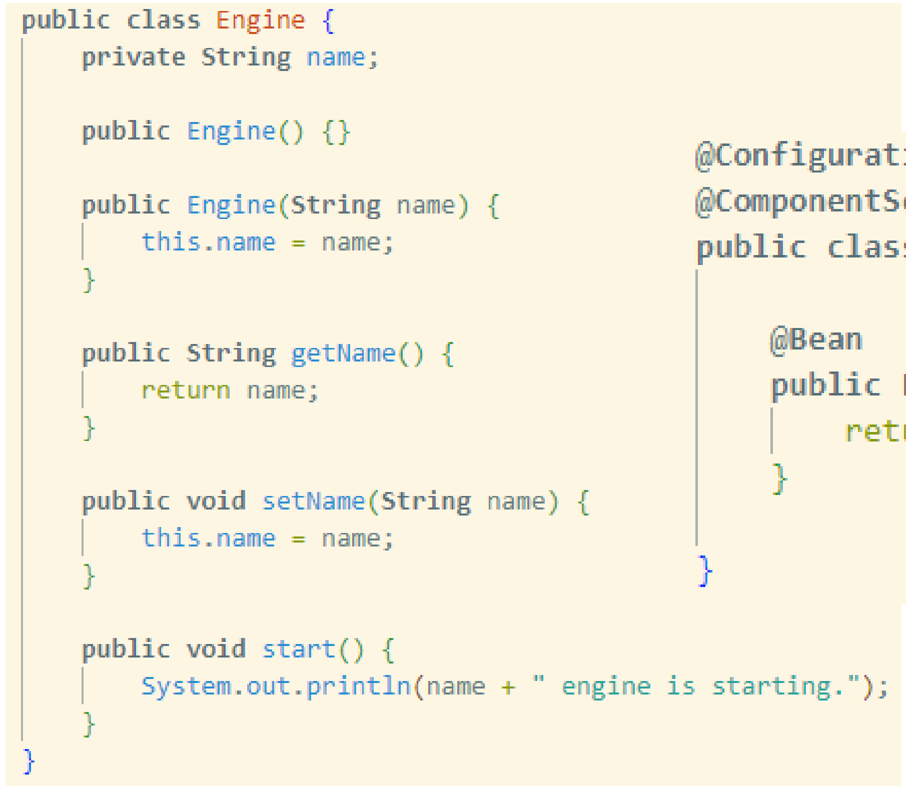


```java
@Configuration
@ComponentScan(basePackages = "com.example")
public class AppConfig {

    @Bean
    public Engine engine() {
        return new Engine("V8");
    }

}
```

A Java-based configuration class
(i.e., a class annotated with @Configuration)

# @Bean

- A bean is an object that is instantiated, assembled, and managed by a Spring IoC container
- @Bean annotation is used within Coto create Spring beans
- Methods annotated with @Bean create and return the actual bean



```java
public class Engine {
    private String name;

    public Engine() {}

    public Engine(String name) {
        this.name = name;
    }

    public String getName() {
        return name;
    }

    public void setName(String name) {
        this.name = name;
    }

    public void start() {
        System.out.println(name + " engine is starting.");
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}
```

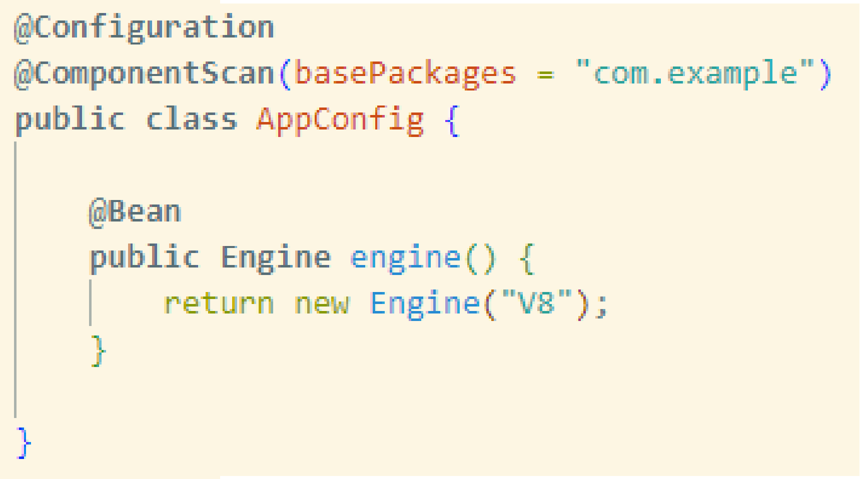

```java
@Configuration
@ComponentScan(basePackages = "com.example")
public class AppConfig {

    @Bean
    public Engine engine() {
        return new Engine("V8");
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}
```
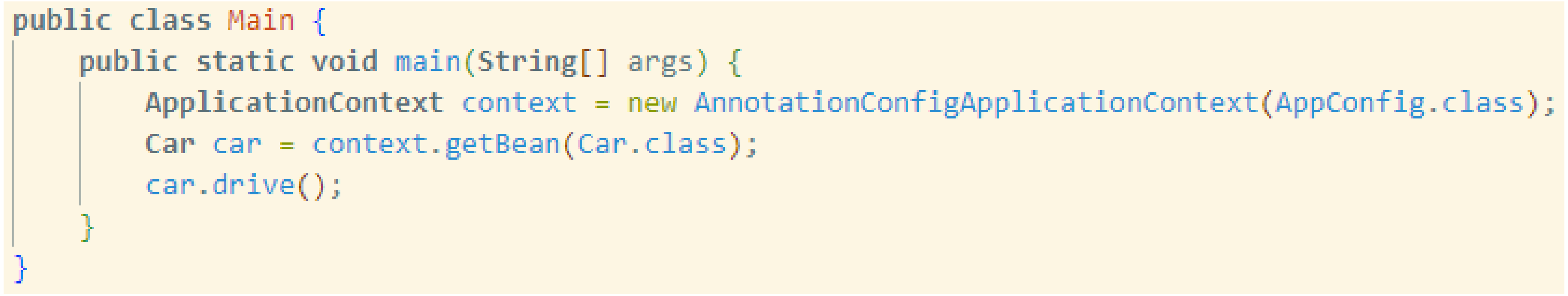

Compared to **`@Component`**, which is a class-level annotation, **`@Bean`** is a method-level annotation that allows for more fine-grained control over bean creation, such as setting parameters at the time of bean instantiation.

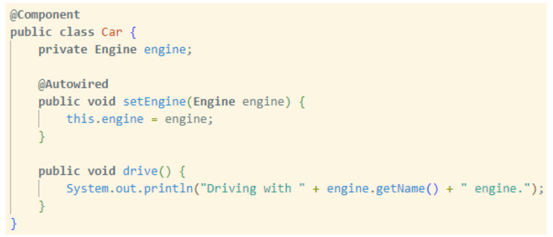
# Spring IoC Container

- Spring IoC container is responsible for instantiating, configuring and assembling objects/beans (using DI), as well as managing their life cycles (hence *the inversion of control*).
- The `ApplicationContext` interface is the commonly used Spring IoC Container
- Your application classes are combined with configuration metadata so that after the `ApplicationContext` is created and initialized, you have a fully configured and executable system or application.



```java
public class Main {
    public static void main(String[] args) {
        ApplicationContext context = new AnnotationConfigApplicationContext(AppConfig.class);
        Car car = context.getBean(Car.class);
        car.drive();
    }
}
```

# To Put it Together



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@Component
public class Car {
    private Engine engine;

    @Autowired
    public void setEngine(Engine engine) {
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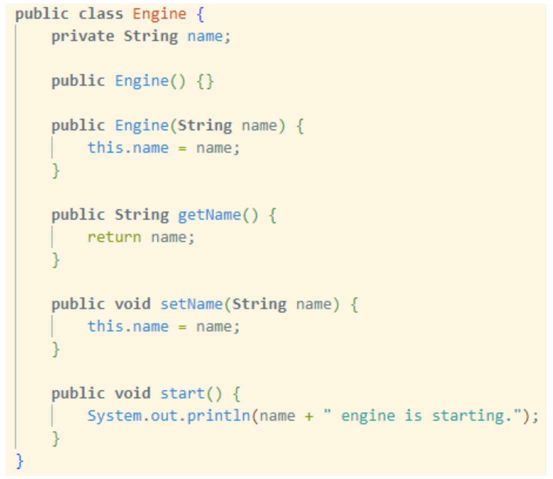
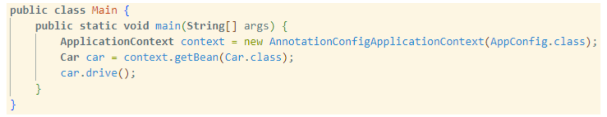
    }

    public void drive() {
        System.out.println("Driving with " + engine.getName() + " engine.");
    }
}
```



```java
public class Engine {
    private String name;

    public Engine() {}

    public Engine(String name) {
        this.name = name;
    }

    public String getName() {
        return name;
    }

    public void setName(String name) {
        this.name = name;
    }

    public void start() {
        System.out.println(name + " engine is starting.");
    }
}
```



```java
public class Main {
    public static void main(String[] args) {
        ApplicationContext context = new AnnotationConfigApplicationContext(AppConfig.class);
        Car car = context.getBean(Car.class);
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}
```
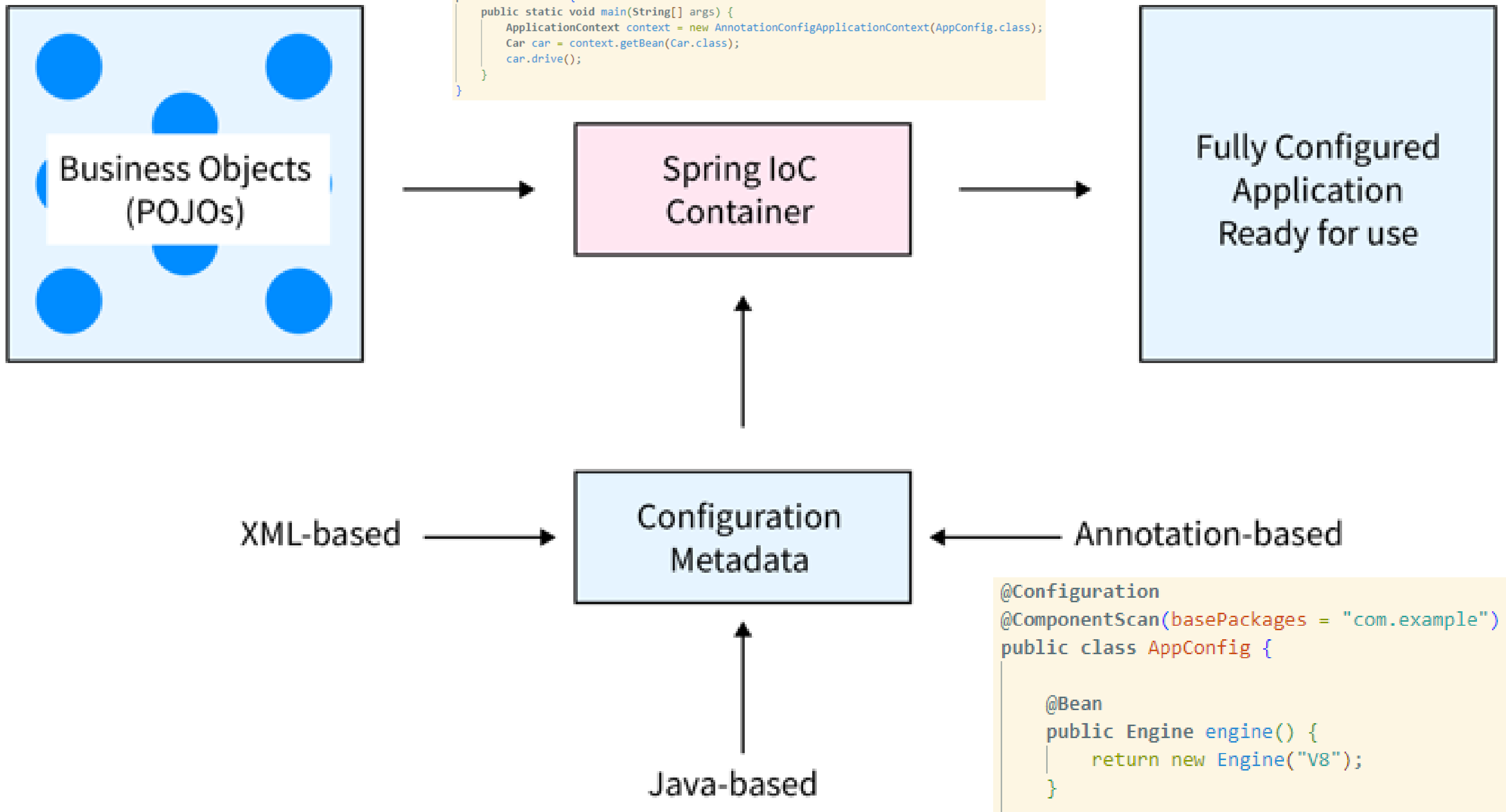
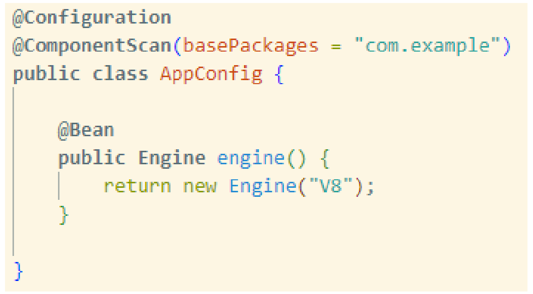





```java
@Configuration
@ComponentScan(basePackages = "com.example")
public class AppConfig {

    @Bean
    public Engine engine() {
        return new Engine("V8");
    }

}
```

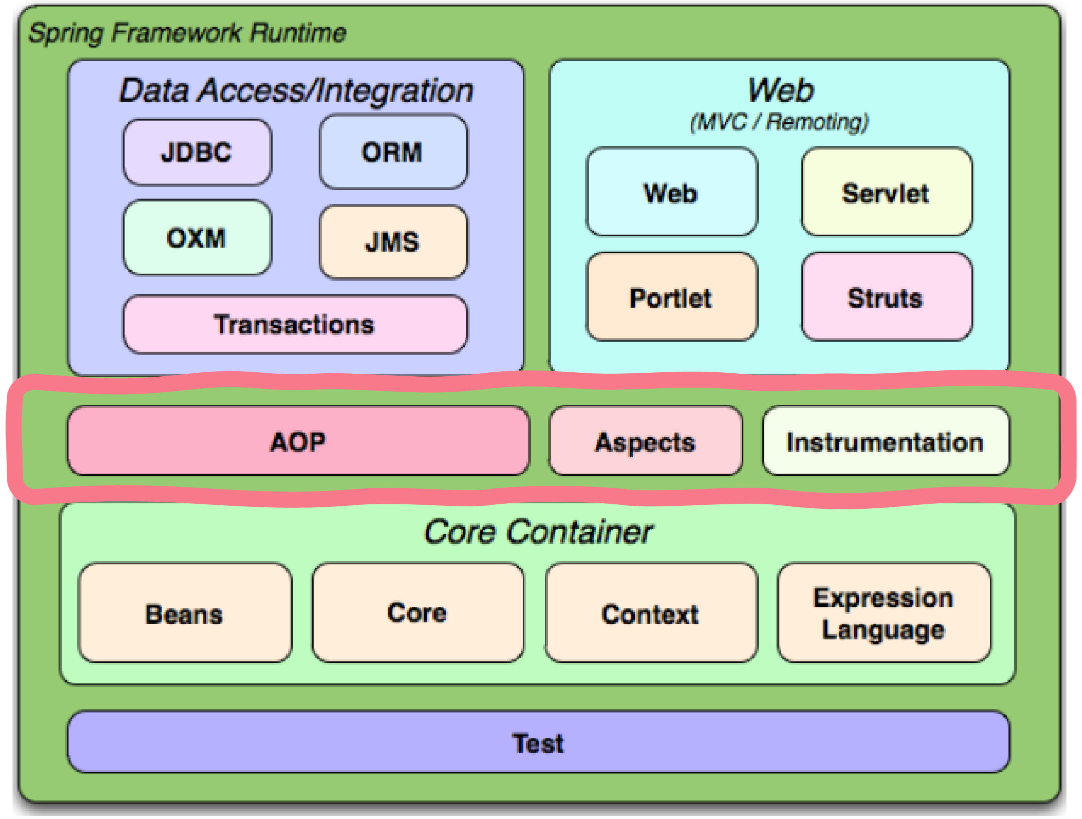
## Dependency Injection

- Dependency Injection (DI): how IoC concept is implemented in Spring.
- Instead of objects creating their dependencies from inside, the dependencies are injected from the outside, by the Spring IoC containers
- Dependency injection decouples the usage of an object (by callers) from its creation (by IoC containers), leading to loosely coupled programs.

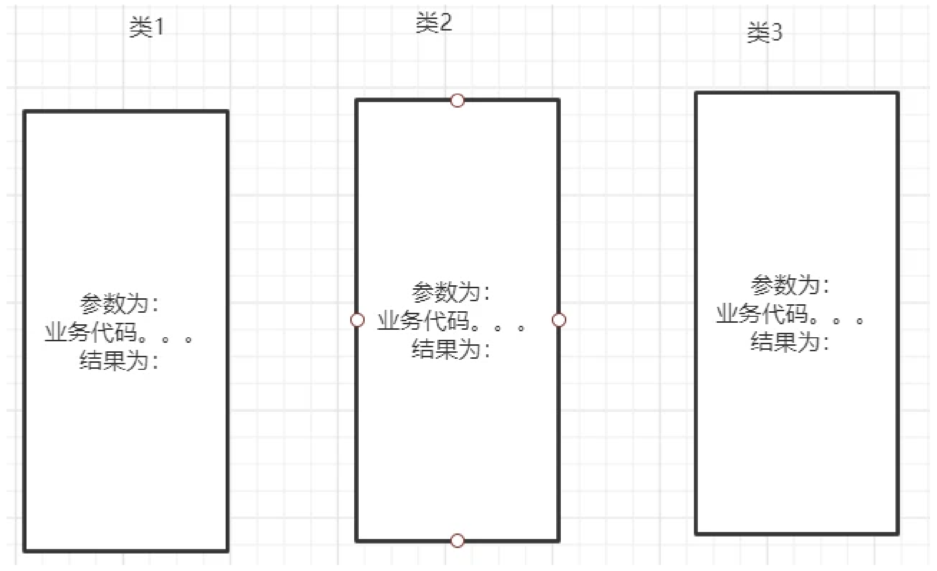
# Spring AOP

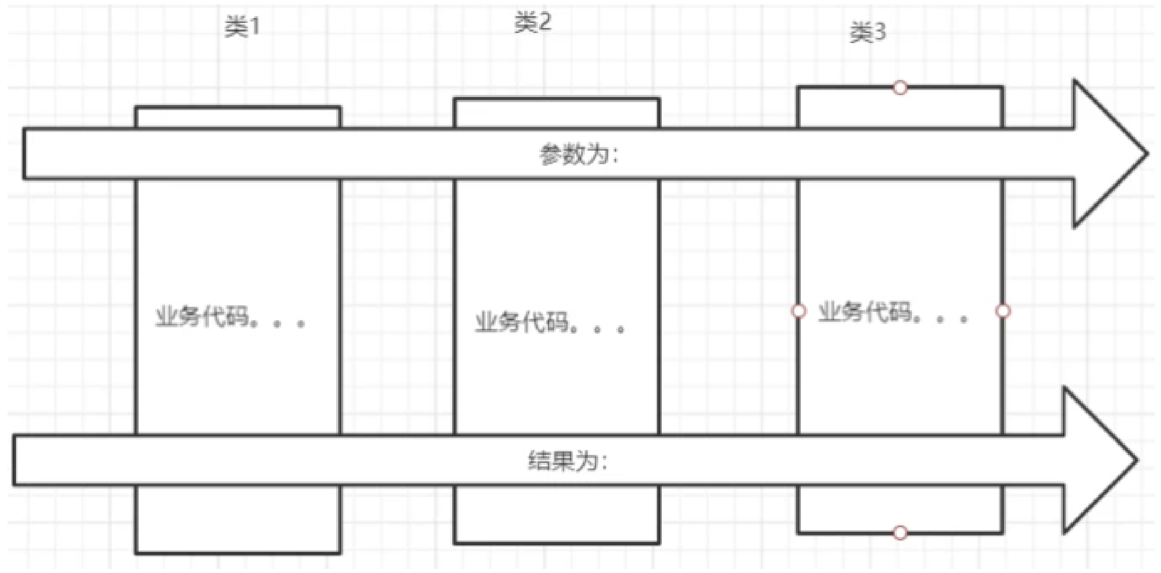
- AOP (Aspect-Oriented Programming, 面向切面编程): a programming paradigm that complements OOP by allowing the separation of cross-cutting concerns (i.e., we could add additional cross-cutting behavior to existing code without modifying the code itself)

- Cross-cutting concerns (横切关注点): a piece of logic or code that is going to be written in multiple classes/layers but is not business logic
  - Logging
  - Security
  - Transaction management
  - …



## Spring AOP



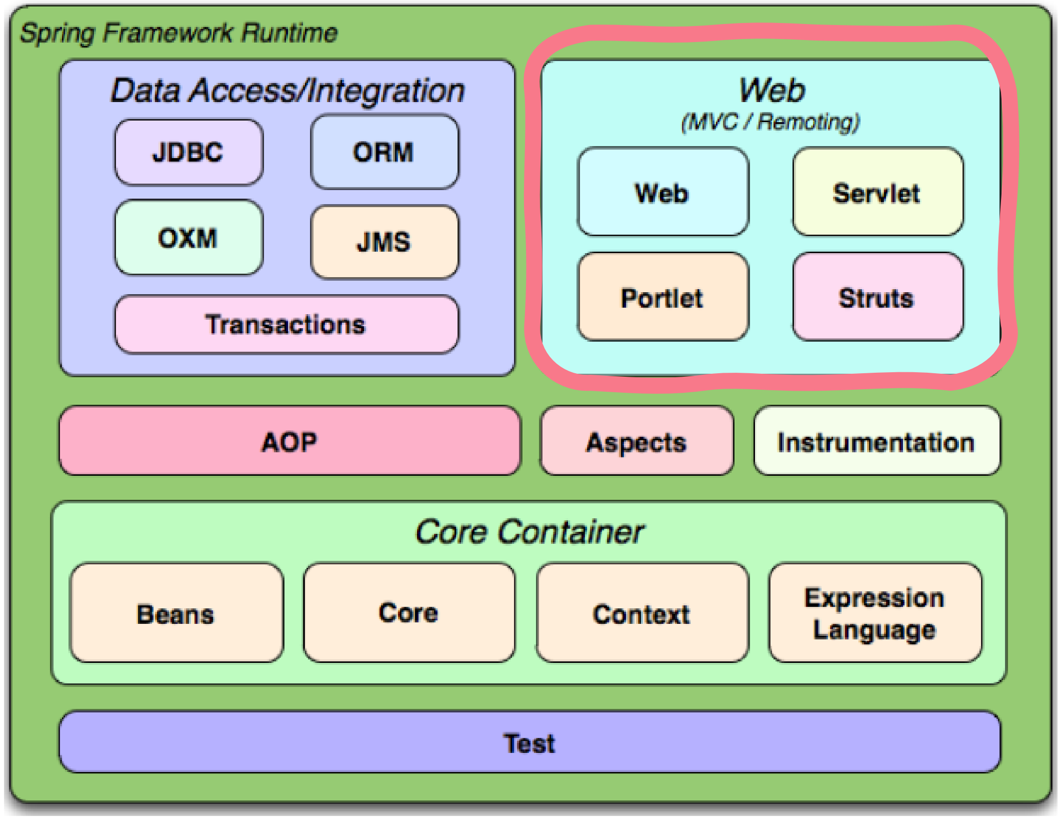


**Without AOP**: business code and non-business code are tangled together

**With AOP**: business code and non-business code are decoupled and can be managed independently.

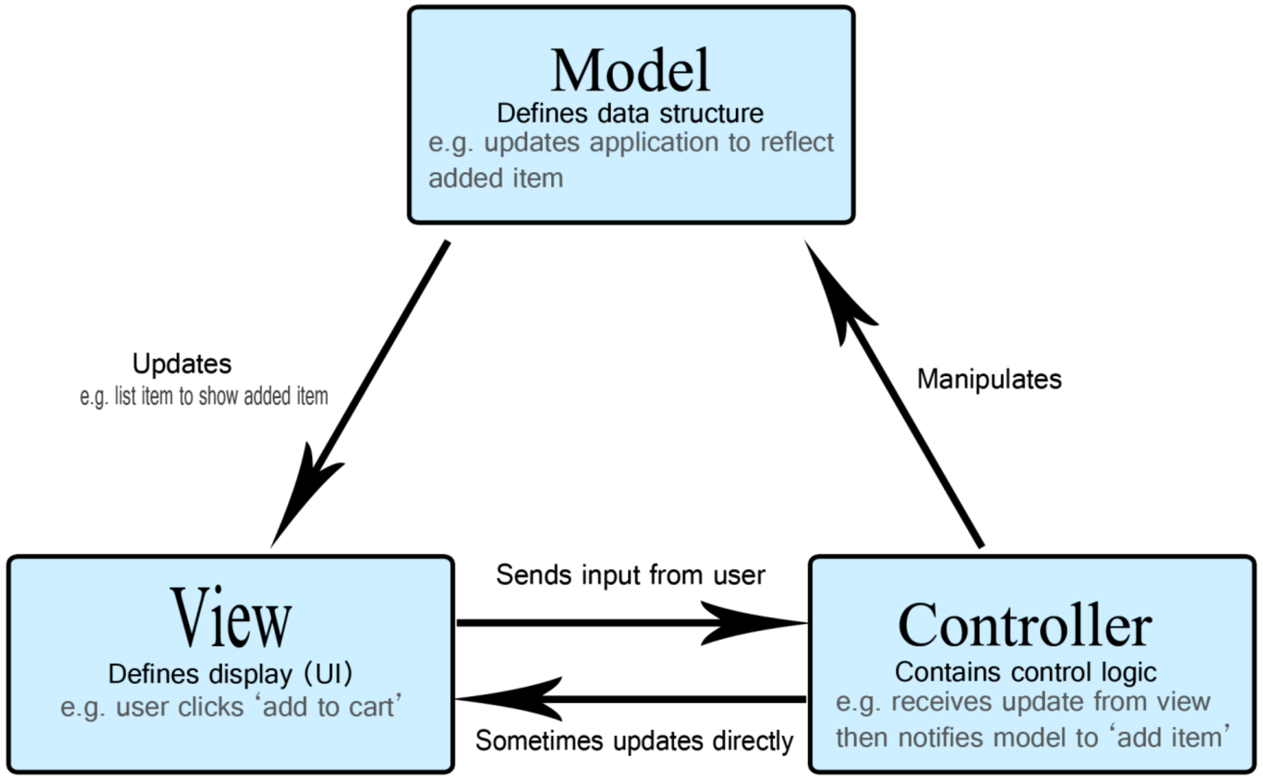
# Spring MVC

- The Web layer consists of the `spring-web`, `spring-webmvc`, `spring-websocket`, and `spring-webmvc-portlet` modules.
- Spring MVC is an integrated version of the Spring framework and Model View Controller
  - It has all the basic features of the core Spring framework like Dependency Injection and Inversion of Control
  - The MVC pattern segregates the application' s different aspects (input logic, business logic, and UI logic)
- Spring MVC (`spring-webmvc`) contains Spring's model-view-controller (MVC) and REST Web Services implementation for web applications.



## MVC Design Pattern

- Model–view–controller (MVC) is a software design pattern commonly used for developing user interfaces that divide the related program logic into three interconnected elements.
  - **Model** directly manages the data, logic and rules of the application
  - **View** represents the visualization of the data that model contains.
  - **Controller** accepts input and converts it to commands for the model or view


Model
Defines data structure
e.g. updates application to reflect added item
Updates
e.g. list item to show added item
Manipulates
View
Defines display (UI)
e.g. user clicks 'add to cart'
Sends input from user
Sometimes updates directly
Controller
Contains control logic
e.g. receives update from view then notifies model to 'add item'

## Spring MVC

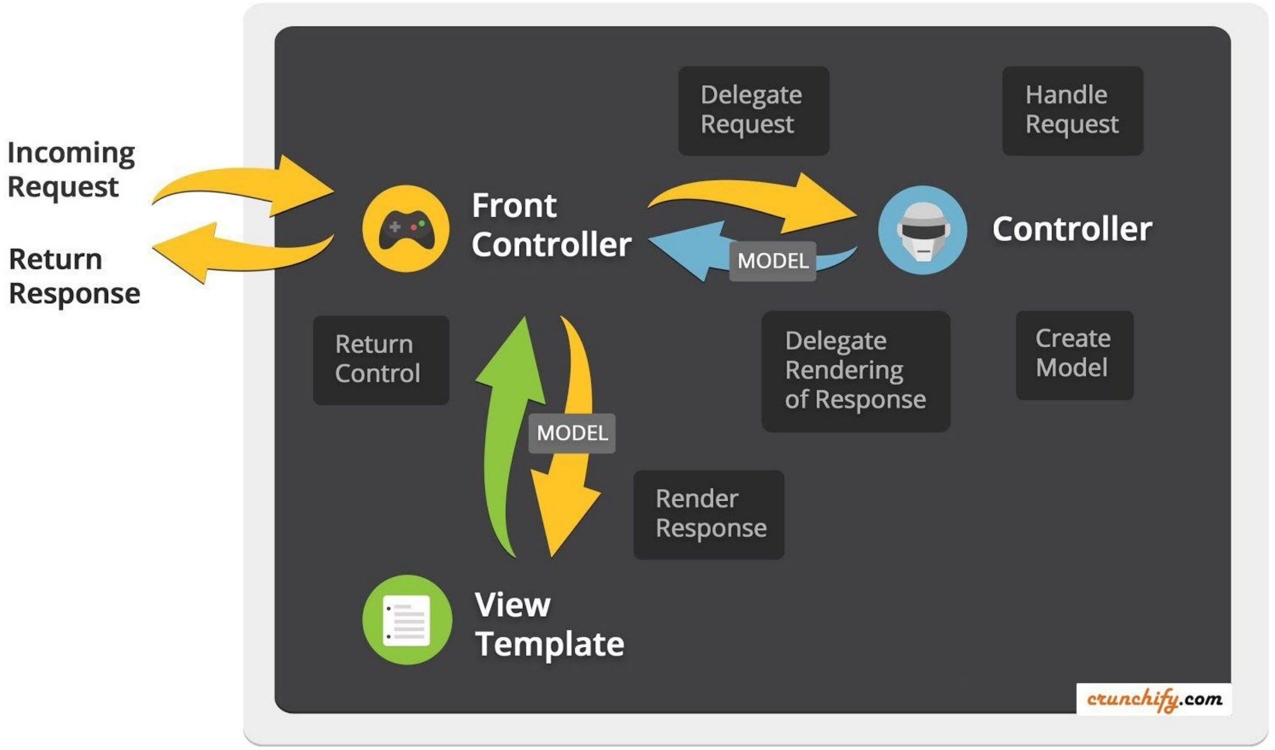
1. The client sends a request, which is intercepted by Front controller (DispatcherServlet)

2. Front controller will dispatch the request to appropriate Controller.

3. The Controller processes the request and returns the Model and View to the Front controller.

4. Front controller dispatches the rendering process to returned View.

5. View renders Model data and returns the response.

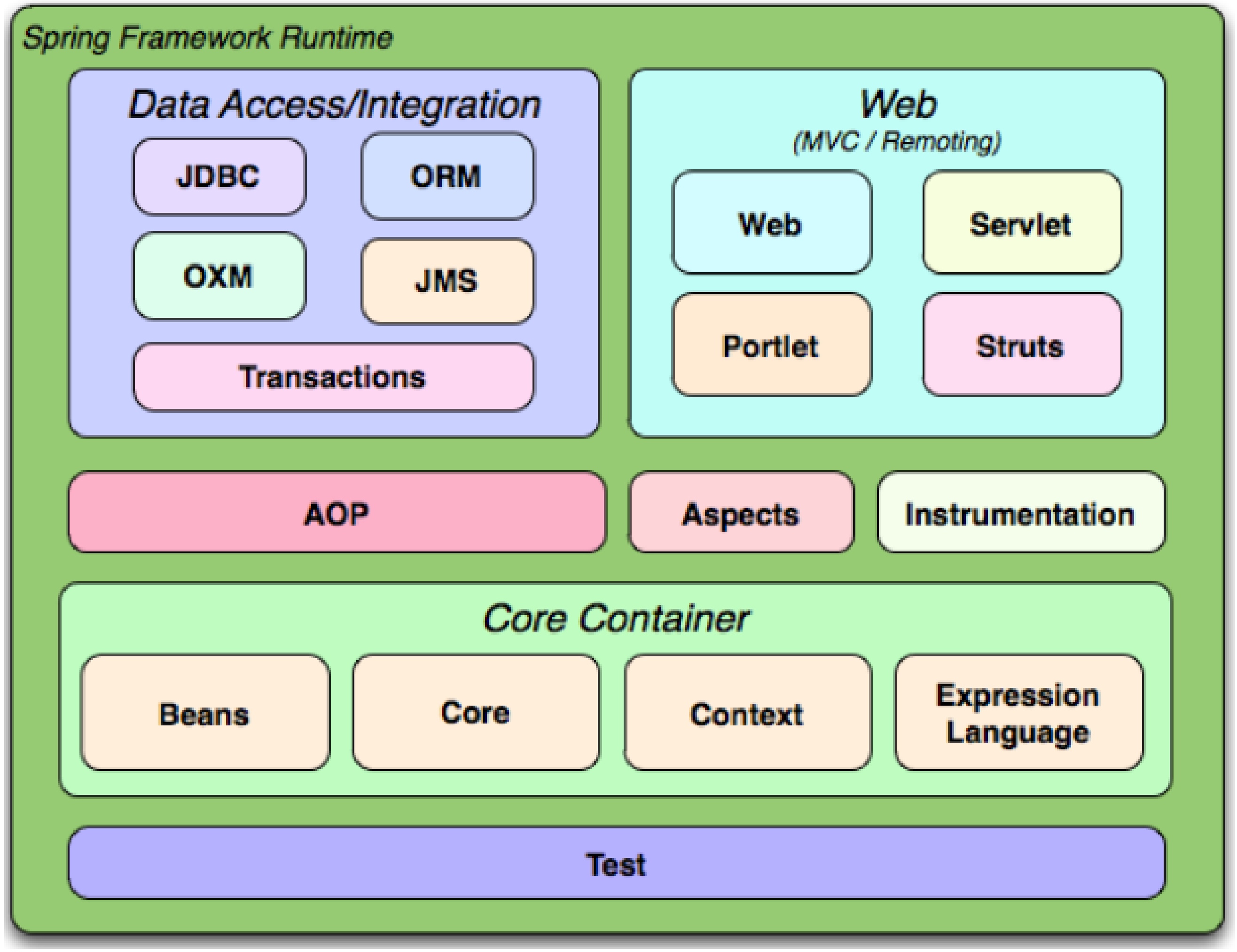


https://crunchify.com/spring-mvc-introduction-to-spring-3-mvc-framework/

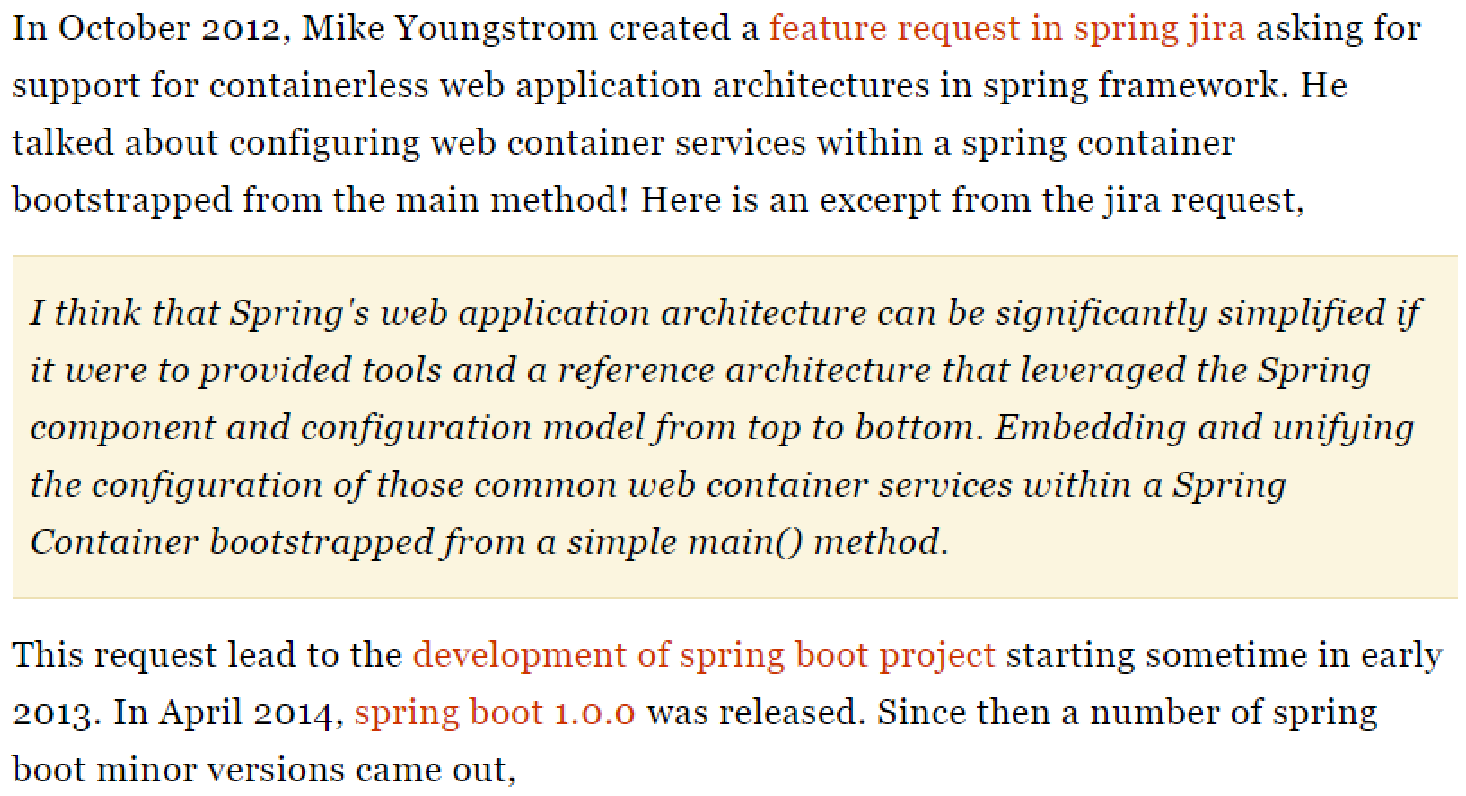
## The Spring Framework

- Core Container
- AOP
- Web

- Data Access/Integration
- Test



## The Origin of Spring Boot



In October 2012, Mike Youngstrom created a feature request in spring jira asking for support for containerless web application architectures in spring framework. He talked about configuring web container services within a spring container bootstrapped from the main method! Here is an excerpt from the jira request,

> *I think that Spring's web application architecture can be significantly simplified if it were to provided tools and a reference architecture that leveraged the Spring component and configuration model from top to bottom. Embedding and unifying the configuration of those common web container services within a Spring Container bootstrapped from a simple main() method.*

This request lead to the development of spring boot project starting sometime in early 2013. In April 2014, spring boot 1.0.0 was released. Since then a number of spring boot minor versions came out,

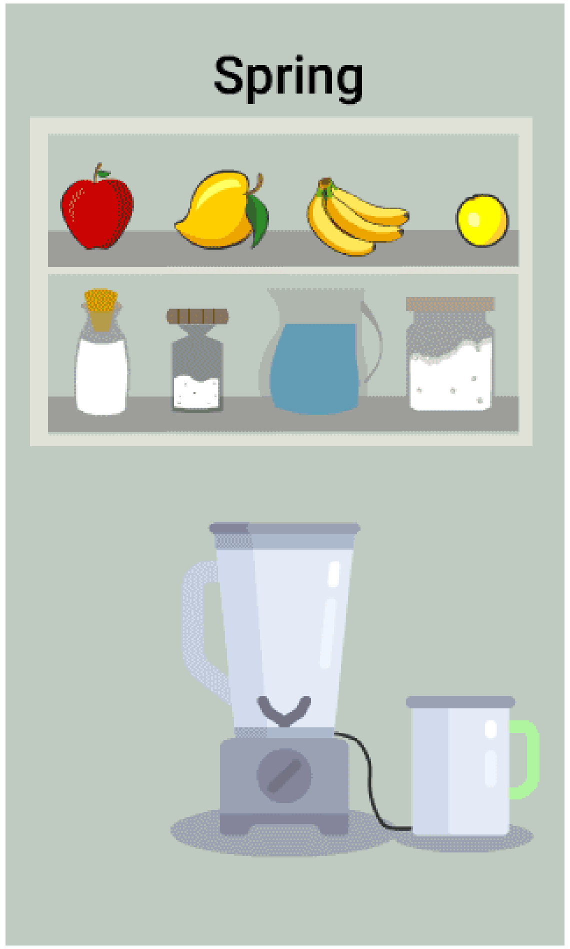
https://www.quickprogrammingtips.com/spring-boot/history-of-spring-framework-and-spring-boot.html

# Lecture 12

- The Spring Framework
  - IoC & Dependency Injection
  - Spring AOP
  - Spring MVC
- Spring Boot
  - Overview
  - Building a MVC web application
  - Building a RESTful web service

# spring boot

- `The Spring Framework` can still be quite complex since developers need to perform many configurations manually (and repetitively!)
- `Spring Boot` simplifies and automates the configuration process and speeds up the creation and deployment of Spring applications (e.g., you could create standalone applications with less or almost no configuration overhead)



https://www.fusion-reactor.com/blog/the-difference-between-spring-framework-vs-spring-boot/

## spring boot

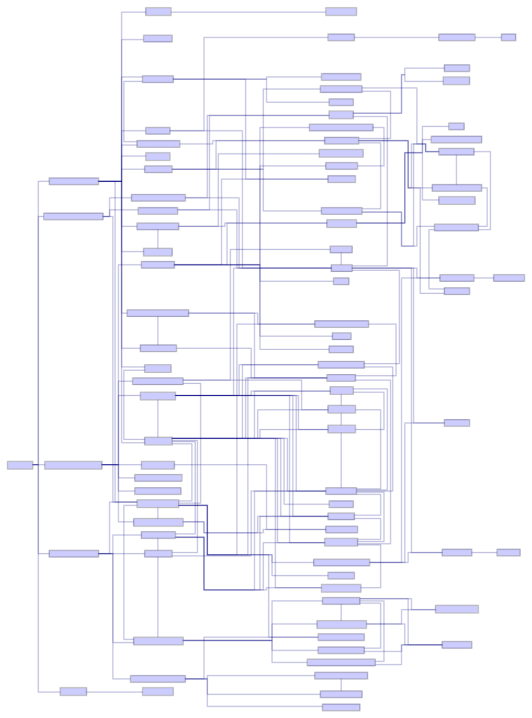
- Spring Boot means bootstrapping a Spring application in such a way that it contains almost everything needed to run a full application.
- Spring Boot auto-configuration attempts to automatically configure your Spring application based on the jar dependencies that you have added.
- Spring Boot takes an **opinionated** view to guide you into their way of configuring things
  - Spring Boot “thinks” that it is the good starting point

https://docs.spring.io/spring-boot/docs/current/reference/htmlsingle/#using.auto-configuration

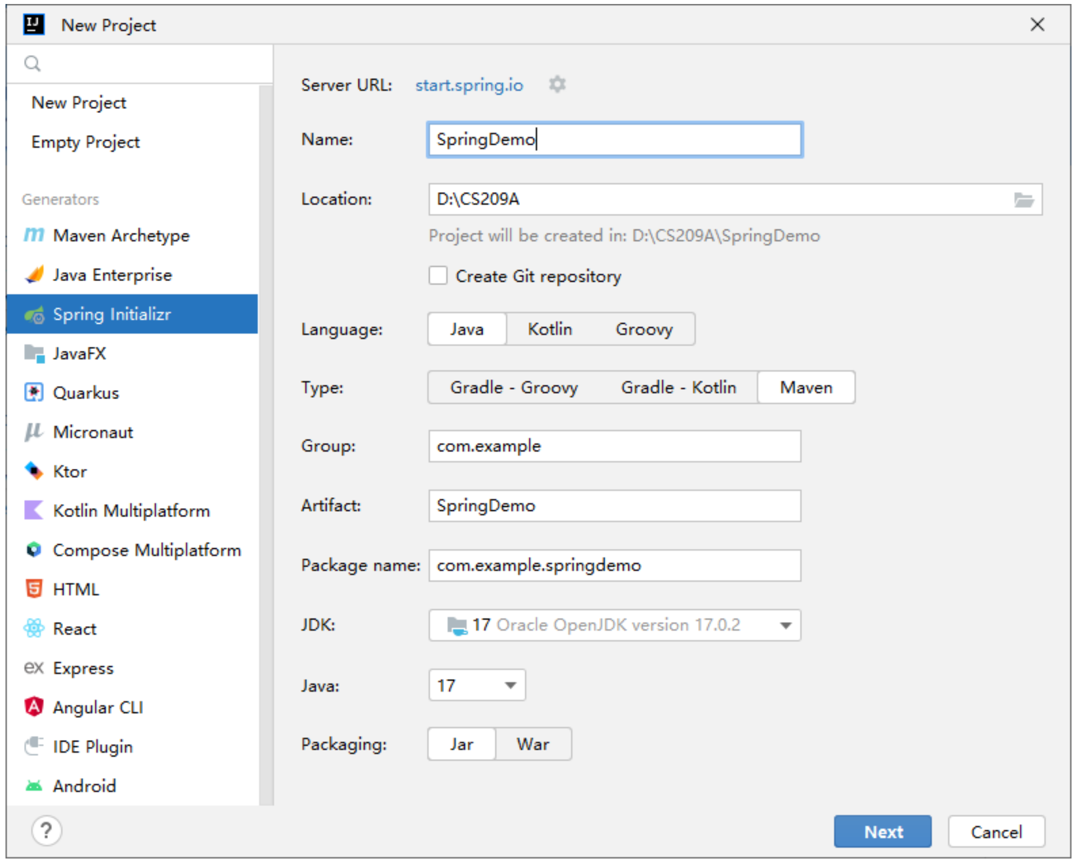
# Creating a web application

- Using `Spring Boot`
  - Create a Spring Boot application using Spring initializer
  - Select dependencies (e.g., Spring Web)
  - Done ☺

- Using `Spring MVC`
  - Download and confi
  - Manually add mave
    - spring-core
    - spring-context
    - spring-aop
    - spring-webmvc
    - spring-web
    - …
  - Configurations
  - More configuration
  - …



# Creating a web app with Spring Initializer



New Project

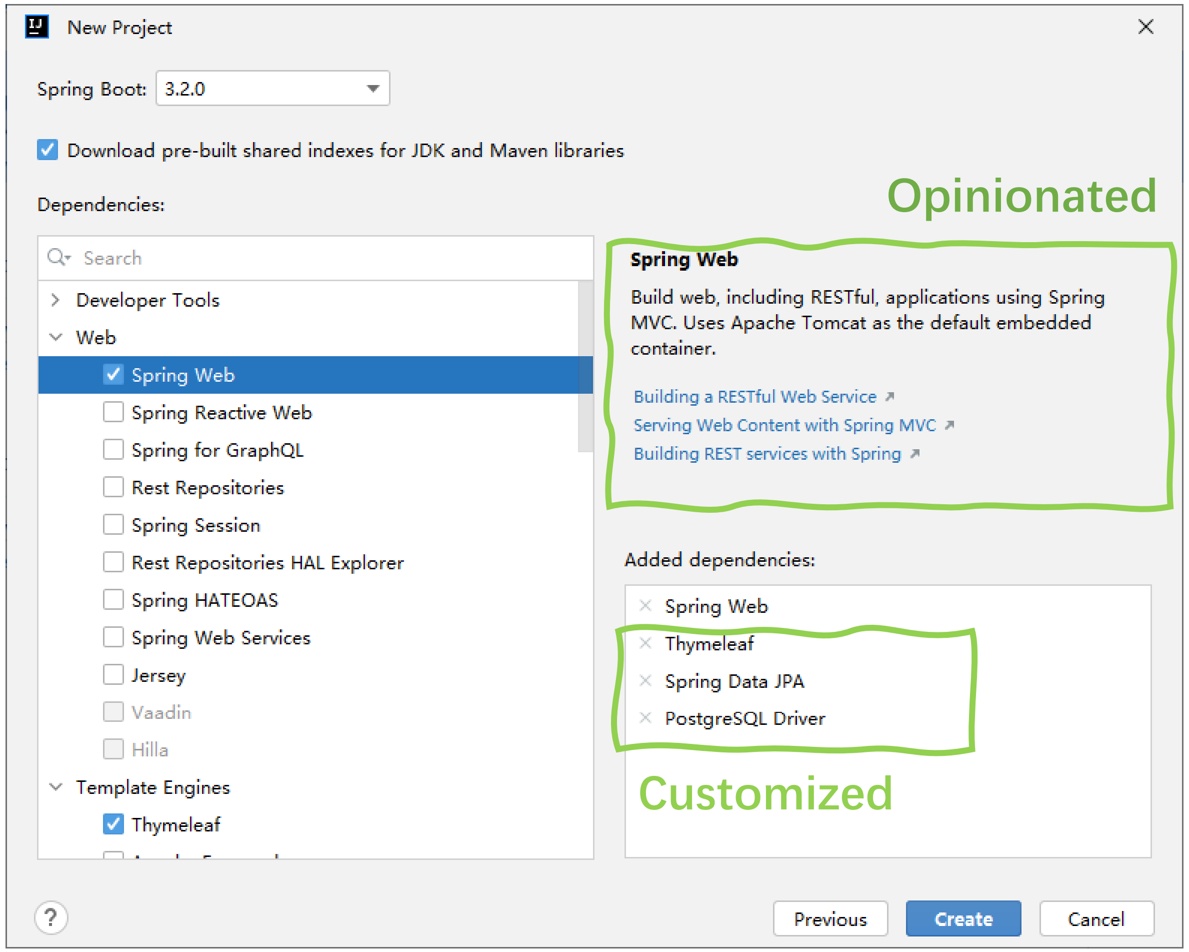
New Project
Empty Project

Generators
Maven Archetype
Java Enterprise
Spring Initializr
JavaFX
Quarkus
Micronaut
Ktor
Kotlin Multiplatform
Compose Multiplatform
HTML
React
Express
Angular CLI
IDE Plugin
Android

| | |
|---|---|
| Server URL: | start.spring.io |
| Name: | SpringDemo |
| Location: | D:\CS209A |
| | Project will be created in: D:\CS209A\SpringDemo |
| | Create Git repository |
| Language: | Java Kotlin Groovy |
| Type: | Gradle - Groovy Gradle - Kotlin Maven |
| Group: | com.example |
| Artifact: | SpringDemo |
| Package name: | com.example.springdemo |
| JDK: | 17 Oracle OpenJDK version 17.0.2 |
| Java: | 17 |
| Packaging: | Jar War |

Next Cancel

**Supported by IntelliJ Ultimate**



New Project

Spring Boot: 3.2.0

☑ Download pre-built shared indexes for JDK and Maven libraries

Dependencies:

Search

- Developer Tools
- Web
  - ☑ Spring Web
  - ☐ Spring Reactive Web
  - ☐ Spring for GraphQL
  - ☐ Rest Repositories
  - ☐ Spring Session
  - ☐ Rest Repositories HAL Explorer
  - ☐ Spring HATEOAS
  - ☐ Spring Web Services
  - ☐ Jersey
  - ☐ Vaadin
  - ☐ Hilla
- Template Engines
  - ☑ Thymeleaf

Opinionated

**Spring Web**

Build web, including RESTful, applications using Spring MVC. Uses Apache Tomcat as the default embedded container.

Building a RESTful Web Service ↗
Serving Web Content with Spring MVC ↗
Building REST services with Spring ↗

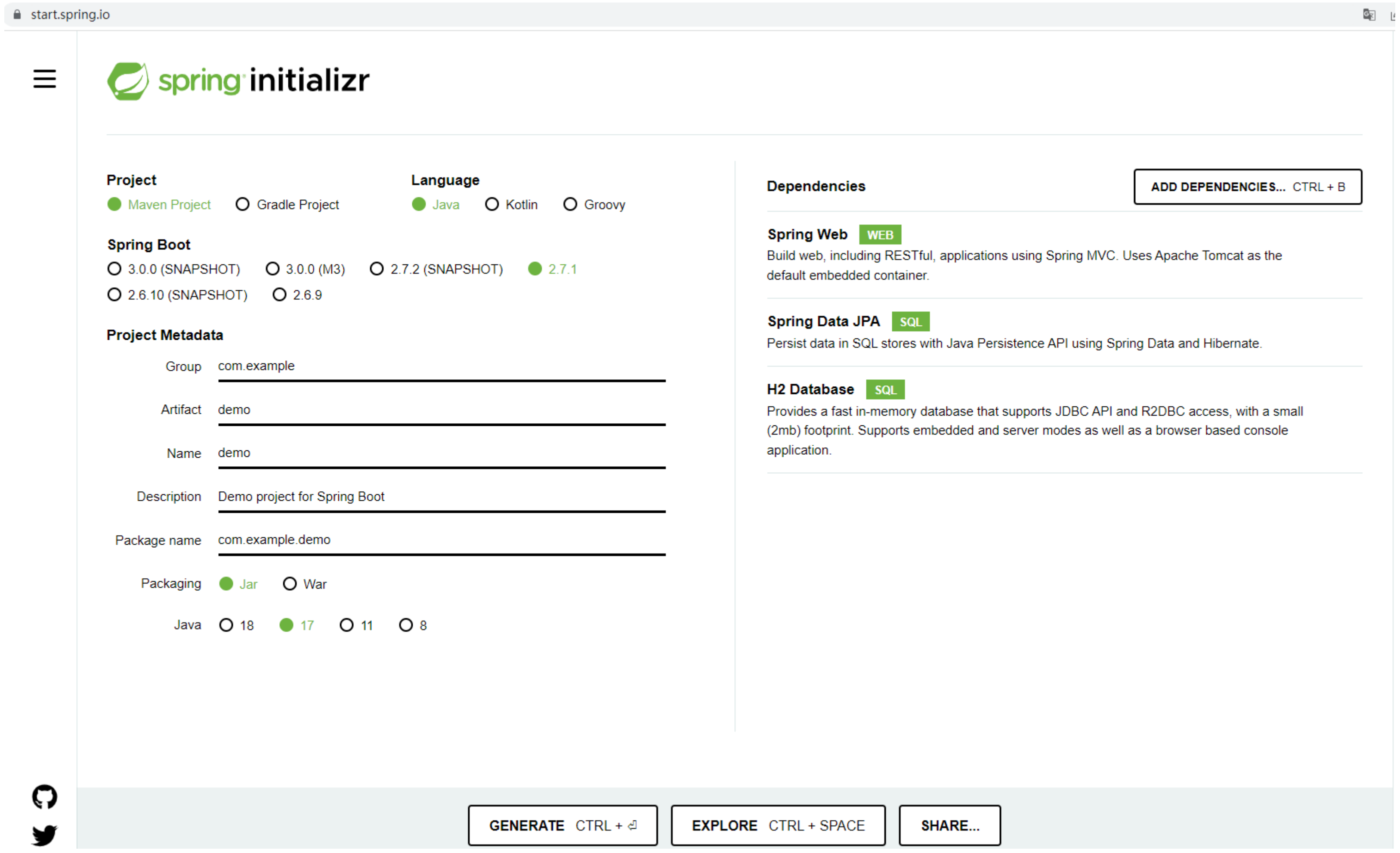
Added dependencies:

- Spring Web
- Thymeleaf
- Spring Data JPA
- PostgreSQL Driver

Customized

Previous Create Cancel

# Creating a web app with Spring Initializer



start.spring.io

spring initializr

**Project**
[✓ Maven Project] Gradle Project

**Language**
[✓ Java] Kotlin Groovy

**Spring Boot**
3.0.0 (SNAPSHOT) 3.0.0 (M3) 2.7.2 (SNAPSHOT) [✓ 2.7.1]
2.6.10 (SNAPSHOT) 2.6.9

**Project Metadata**

| | |
|---|---|
| Group | com.example |
| Artifact | demo |
| Name | demo |
| Description | Demo project for Spring Boot |
| Package name | com.example.demo |
| Packaging | [✓ Jar] War |
| Java | 18 [✓ 17] 11 8 |

**Dependencies**

ADD DEPENDENCIES... CTRL + B

**Spring Web** WEB
Build web, including RESTful, applications using Spring MVC. Uses Apache Tomcat as the default embedded container.

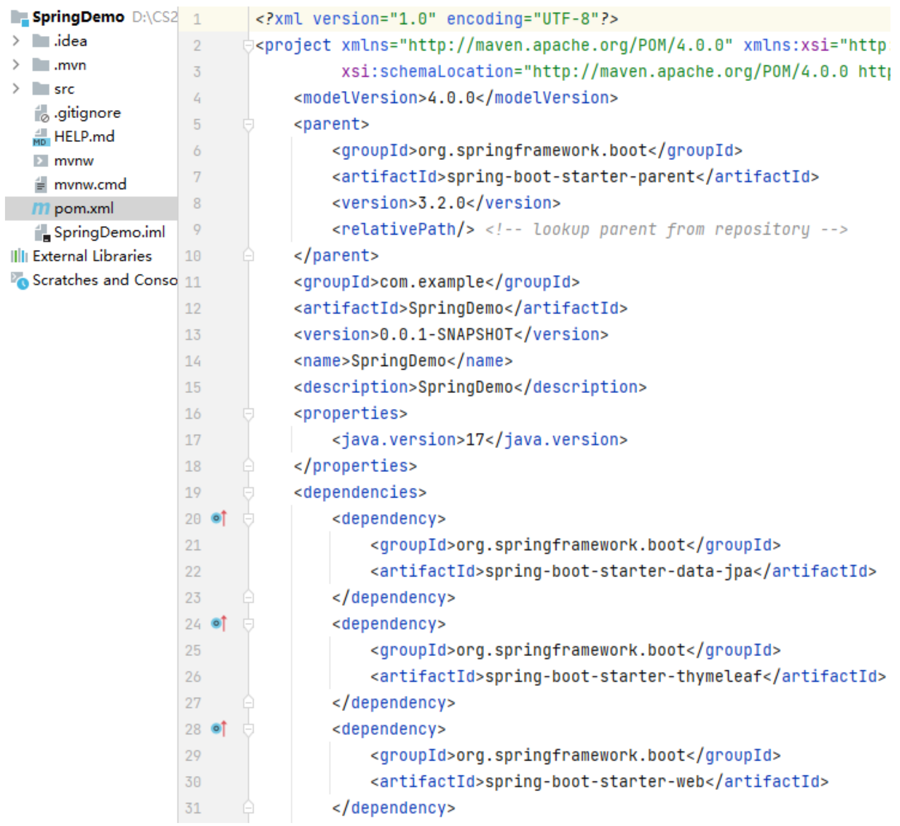
**Spring Data JPA** SQL
Persist data in SQL stores with Java Persistence API using Spring Data and Hibernate.

**H2 Database** SQL
Provides a fast in-memory database that supports JDBC API and R2DBC access, with a small (2mb) footprint. Supports embedded and server modes as well as a browser based console application.

Generate & download the project, then open in IntelliJ

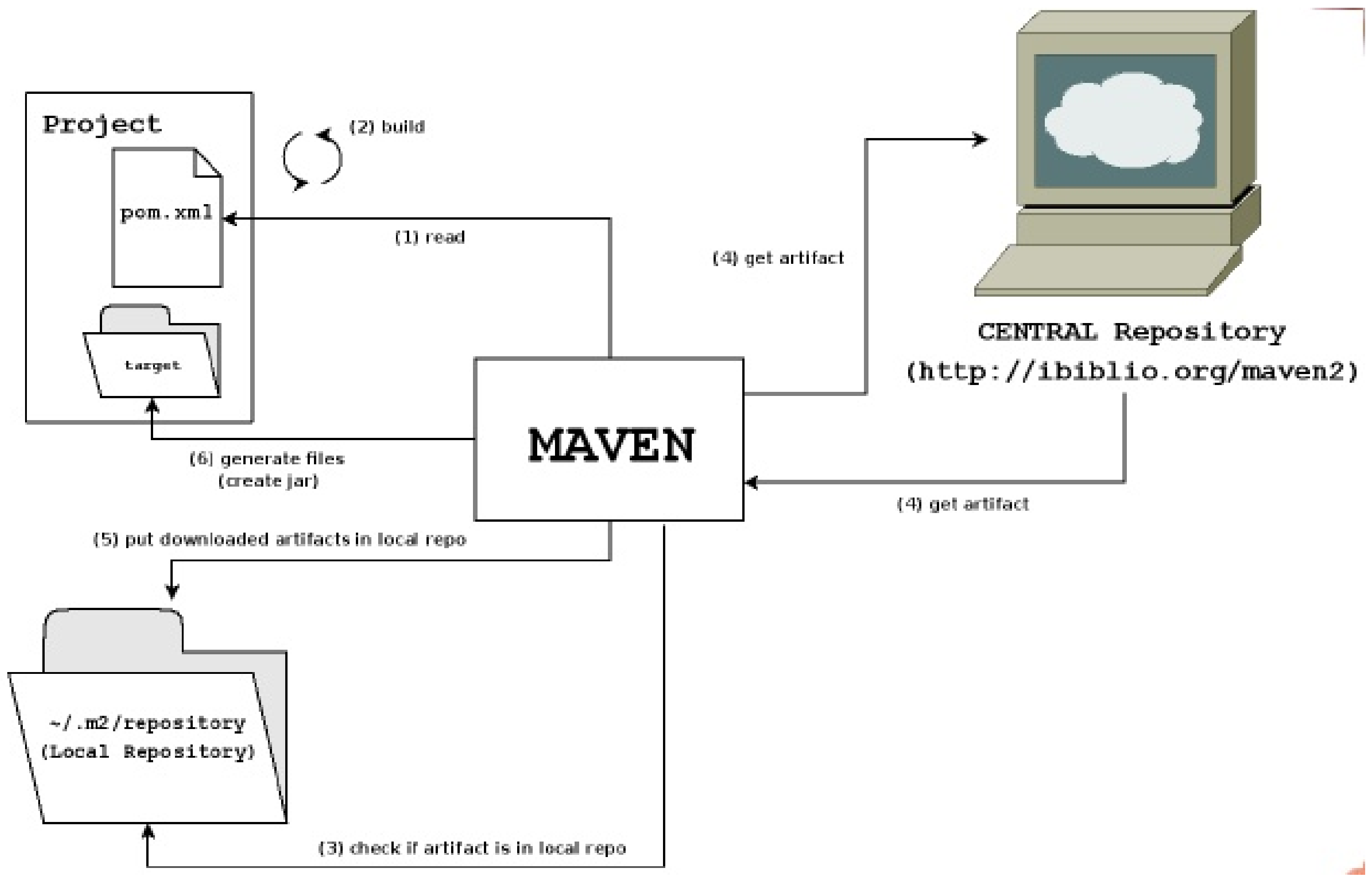
## Maven Dependencies

- POM stands for "Project Object Model". It is an XML representation of a Maven project held in a file named `pom.xml`.
- The `pom.xml` file is the core of a project's configuration in Maven.
- It is a single configuration file that contains the majority of information and dependency required to build a project in just the way you want.



```xml
<?xml version="1.0" encoding="UTF-8"?>
<project xmlns="http://maven.apache.org/POM/4.0.0" xmlns:xsi="http
         xsi:schemaLocation="http://maven.apache.org/POM/4.0.0 htt
    <modelVersion>4.0.0</modelVersion>
    <parent>
        <groupId>org.springframework.boot</groupId>
        <artifactId>spring-boot-starter-parent</artifactId>
        <version>3.2.0</version>
        <relativePath/> <!-- lookup parent from repository -->
    </parent>
    <groupId>com.example</groupId>
    <artifactId>SpringDemo</artifactId>
    <version>0.0.1-SNAPSHOT</version>
    <name>SpringDemo</name>
    <description>SpringDemo</description>
    <properties>
        <java.version>17</java.version>
    </properties>
    <dependencies>
        <dependency>
            <groupId>org.springframework.boot</groupId>
            <artifactId>spring-boot-starter-data-jpa</artifactId>
        </dependency>
        <dependency>
            <groupId>org.springframework.boot</groupId>
            <artifactId>spring-boot-starter-thymeleaf</artifactId>
        </dependency>
        <dependency>
            <groupId>org.springframework.boot</groupId>
            <artifactId>spring-boot-starter-web</artifactId>
        </dependency>
```

## Maven Workflow

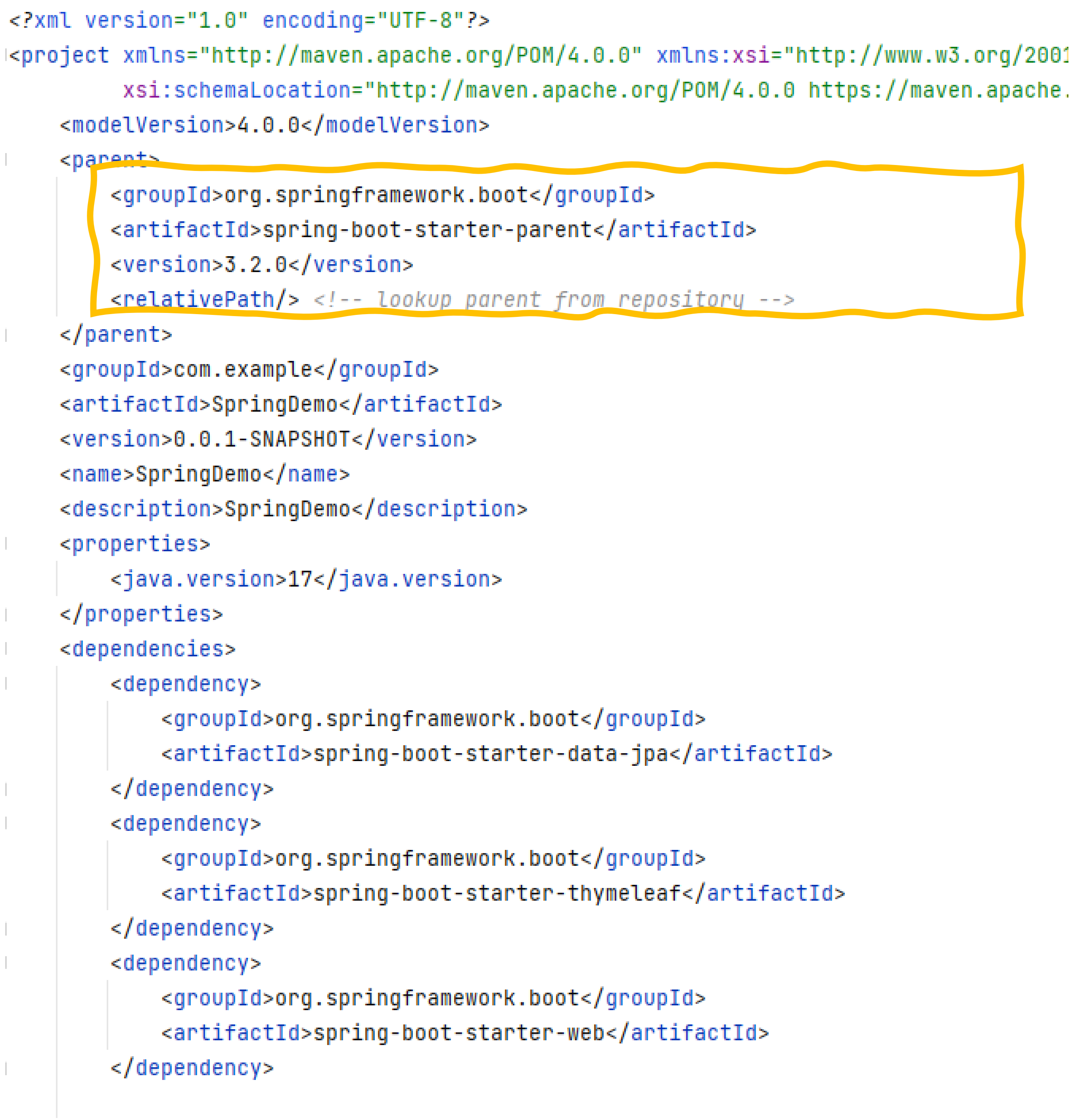


https://www.slideshare.net/sandeepchawla/maven-introduction

## spring-boot-starter-parent

A special starter project that sets up

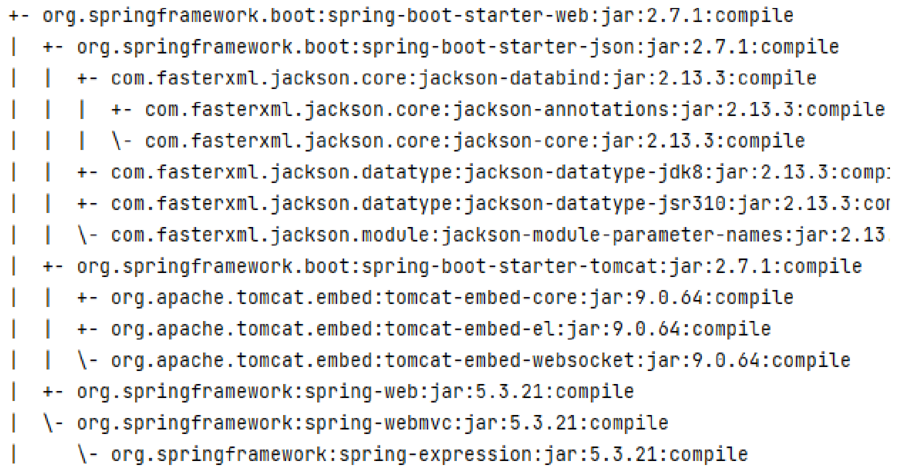
- Default Maven plugins
- Default dependencies & version management
- Default properties & configurations
- …



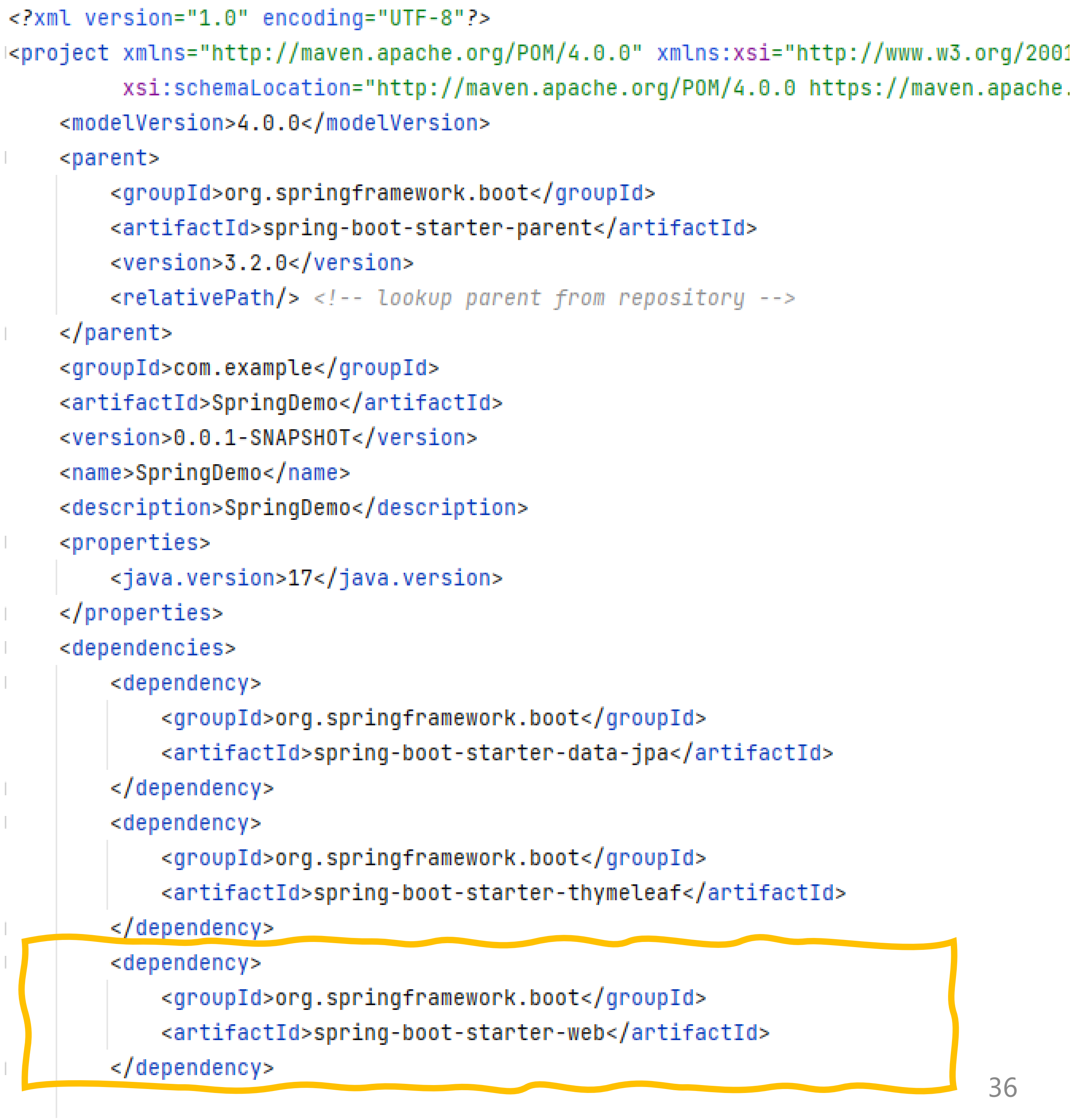
```
<?xml version="1.0" encoding="UTF-8"?>
<project xmlns="http://maven.apache.org/POM/4.0.0" xmlns:xsi="http://www.w3.org/2001
         xsi:schemaLocation="http://maven.apache.org/POM/4.0.0 https://maven.apache.
    <modelVersion>4.0.0</modelVersion>
    <parent>
        <groupId>org.springframework.boot</groupId>
        <artifactId>spring-boot-starter-parent</artifactId>
        <version>3.2.0</version>
        <relativePath/> <!-- lookup parent from repository -->
    </parent>
    <groupId>com.example</groupId>
    <artifactId>SpringDemo</artifactId>
    <version>0.0.1-SNAPSHOT</version>
    <name>SpringDemo</name>
    <description>SpringDemo</description>
    <properties>
        <java.version>17</java.version>
    </properties>
    <dependencies>
        <dependency>
            <groupId>org.springframework.boot</groupId>
            <artifactId>spring-boot-starter-data-jpa</artifactId>
        </dependency>
        <dependency>
            <groupId>org.springframework.boot</groupId>
            <artifactId>spring-boot-starter-thymeleaf</artifactId>
        </dependency>
        <dependency>
            <groupId>org.springframework.boot</groupId>
            <artifactId>spring-boot-starter-web</artifactId>
        </dependency>
```

## spring-boot-starter-web

transitively pulls in all dependencies related to web development



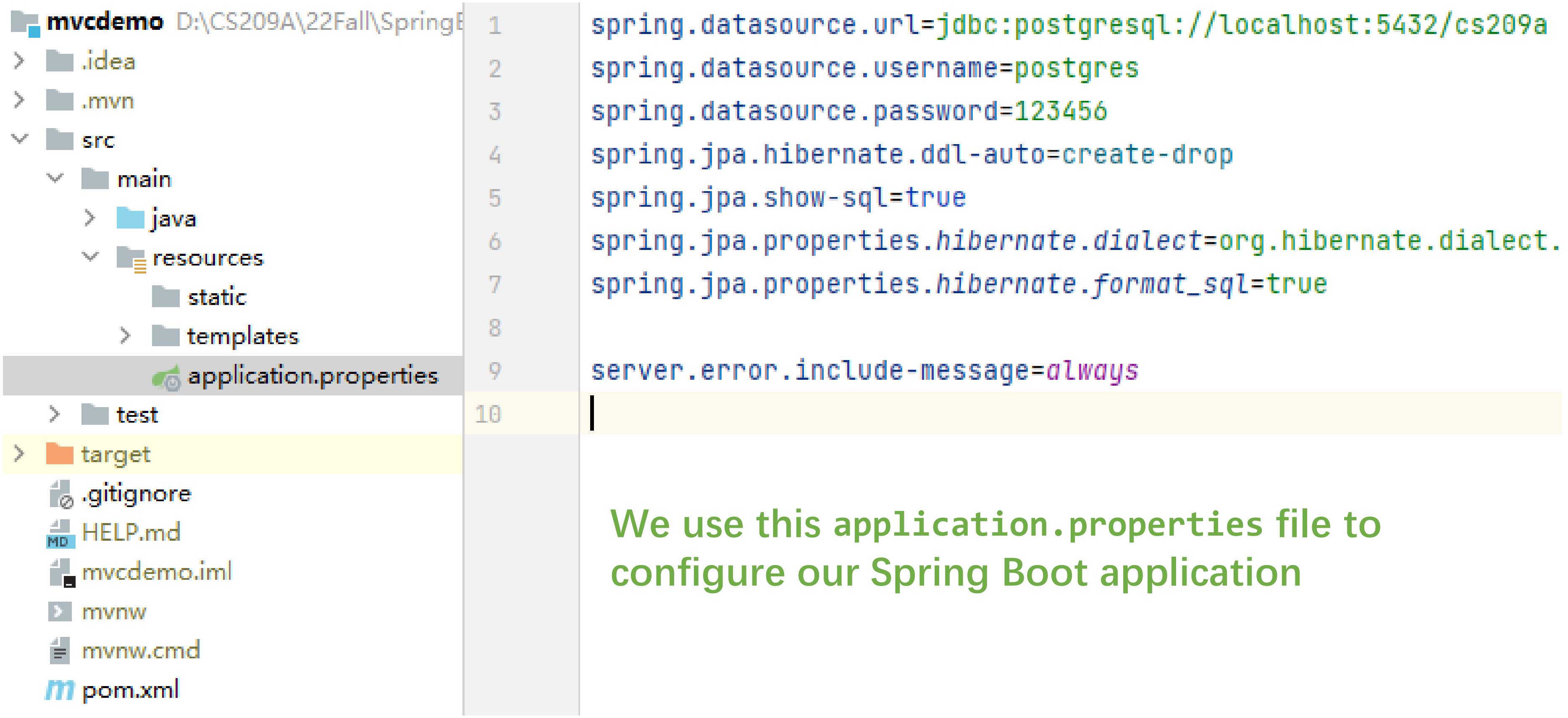
```
+- org.springframework.boot:spring-boot-starter-web:jar:2.7.1:compile
|  +- org.springframework.boot:spring-boot-starter-json:jar:2.7.1:compile
|  |  +- com.fasterxml.jackson.core:jackson-databind:jar:2.13.3:compile
|  |  |  +- com.fasterxml.jackson.core:jackson-annotations:jar:2.13.3:compile
|  |  |  \- com.fasterxml.jackson.core:jackson-core:jar:2.13.3:compile
|  |  +- com.fasterxml.jackson.datatype:jackson-datatype-jdk8:jar:2.13.3:comp
|  |  +- com.fasterxml.jackson.datatype:jackson-datatype-jsr310:jar:2.13.3:co
|  |  \- com.fasterxml.jackson.module:jackson-module-parameter-names:jar:2.13
|  +- org.springframework.boot:spring-boot-starter-tomcat:jar:2.7.1:compile
|  |  +- org.apache.tomcat.embed:tomcat-embed-core:jar:9.0.64:compile
|  |  +- org.apache.tomcat.embed:tomcat-embed-el:jar:9.0.64:compile
|  |  \- org.apache.tomcat.embed:tomcat-embed-websocket:jar:9.0.64:compile
|  +- org.springframework:spring-web:jar:5.3.21:compile
|  \- org.springframework:spring-webmvc:jar:5.3.21:compile
|     \- org.springframework:spring-expression:jar:5.3.21:compile
```



```xml
<?xml version="1.0" encoding="UTF-8"?>
<project xmlns="http://maven.apache.org/POM/4.0.0" xmlns:xsi="http://www.w3.org/2001
         xsi:schemaLocation="http://maven.apache.org/POM/4.0.0 https://maven.apache.
    <modelVersion>4.0.0</modelVersion>
    <parent>
        <groupId>org.springframework.boot</groupId>
        <artifactId>spring-boot-starter-parent</artifactId>
        <version>3.2.0</version>
        <relativePath/> <!-- lookup parent from repository -->
    </parent>
    <groupId>com.example</groupId>
    <artifactId>SpringDemo</artifactId>
    <version>0.0.1-SNAPSHOT</version>
    <name>SpringDemo</name>
    <description>SpringDemo</description>
    <properties>
        <java.version>17</java.version>
    </properties>
    <dependencies>
        <dependency>
            <groupId>org.springframework.boot</groupId>
            <artifactId>spring-boot-starter-data-jpa</artifactId>
        </dependency>
        <dependency>
            <groupId>org.springframework.boot</groupId>
            <artifactId>spring-boot-starter-thymeleaf</artifactId>
        </dependency>
        <dependency>
            <groupId>org.springframework.boot</groupId>
            <artifactId>spring-boot-starter-web</artifactId>
        </dependency>
```

# Application Properties

1.Core Properties
2.Cache Properties
3.Mail Properties
4.JSON Properties
5.Data Properties
6.Transaction Properties
7.Data Migration Properties
8.Integration Properties
9.Web Properties
10.Templating Properties
11.Server Properties
12.Security Properties
13.RSocket Properties
14.Actuator Properties
15.DevTools Properties
16.Testing Properties



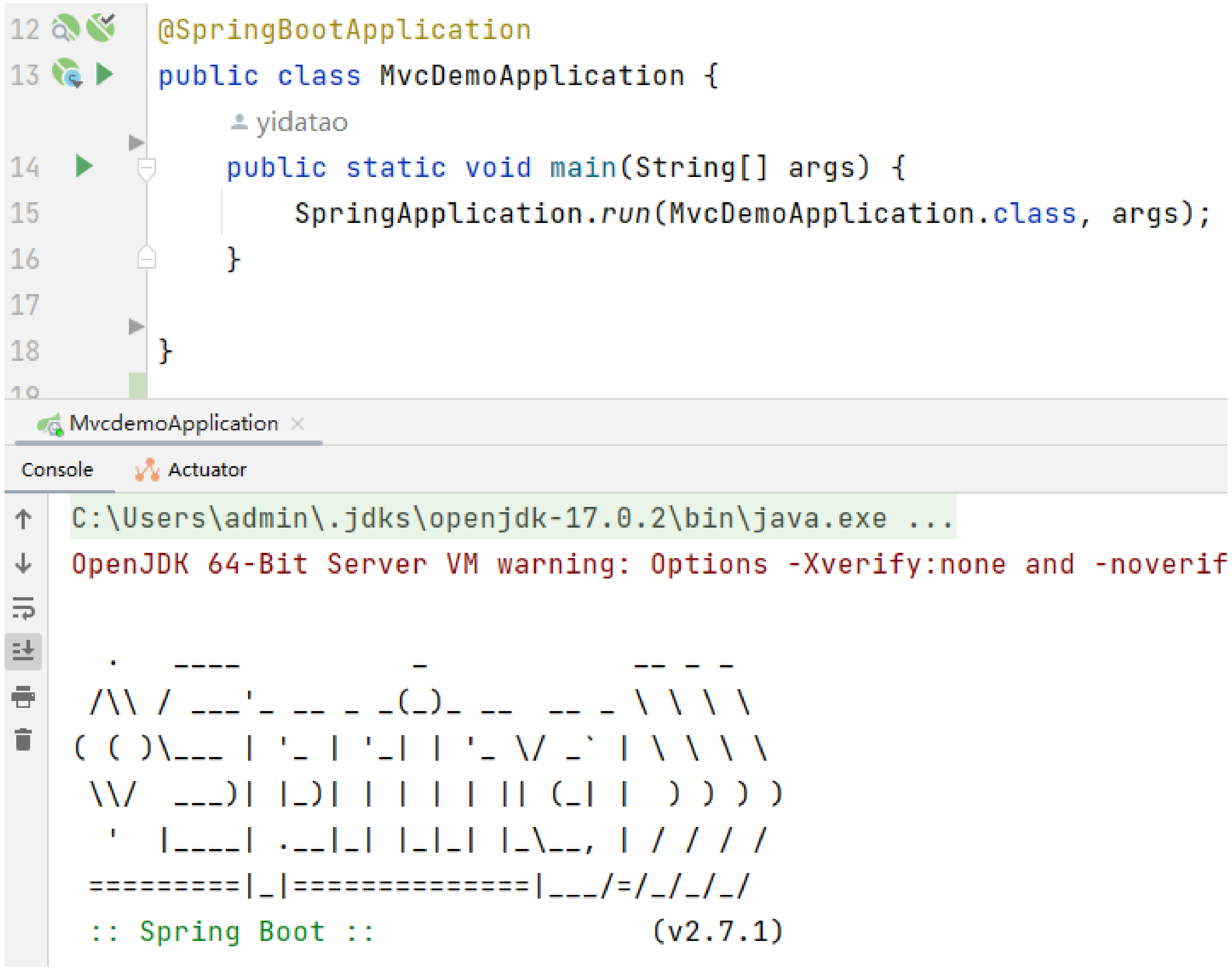
```
spring.datasource.url=jdbc:postgresql://localhost:5432/cs209a
spring.datasource.username=postgres
spring.datasource.password=123456
spring.jpa.hibernate.ddl-auto=create-drop
spring.jpa.show-sql=true
spring.jpa.properties.hibernate.dialect=org.hibernate.dialect.
spring.jpa.properties.hibernate.format_sql=true

server.error.include-message=always

```

We use this `application.properties` file to configure our Spring Boot application

## Application Class

- `@SpringBootApplication` annotation enables 3 features:

  - `@Configuration`: allow to register extra beans in the context or import additional configuration classes
  - `@ComponentScan`: enable @Component scan on the package where the application is located
  - `@EnableAutoConfiguration`: enable Spring Boot's auto-configuration mechanism



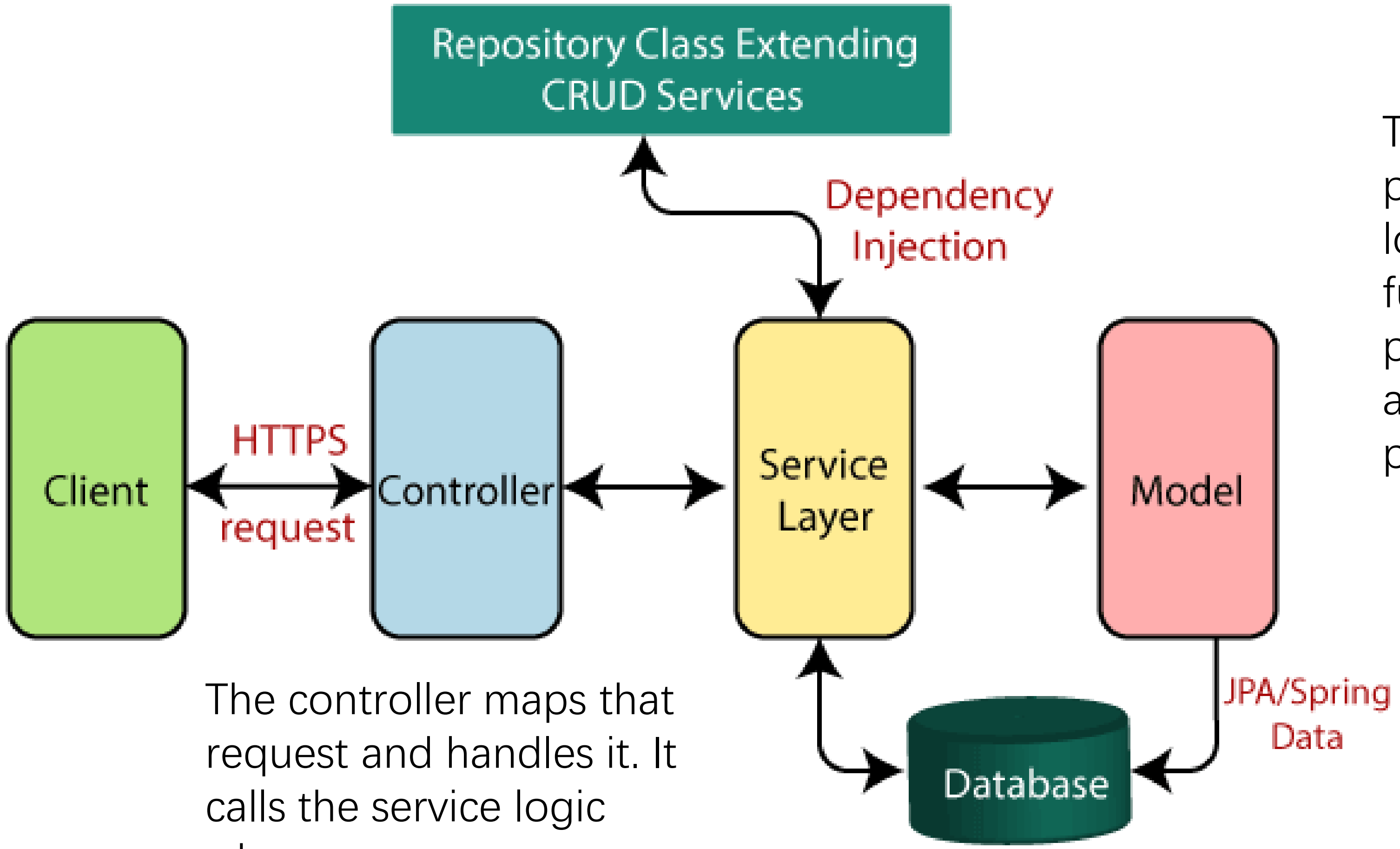
```java
@SpringBootApplication
public class MvcDemoApplication {
        yidatao
    public static void main(String[] args) {
        SpringApplication.run(MvcDemoApplication.class, args);
    }

}
```

```
C:\Users\admin\.jdks\openjdk-17.0.2\bin\java.exe ...
OpenJDK 64-Bit Server VM warning: Options -Xverify:none and -noverif

  .   ____          _            __ _ _
 /\\ / ___'_ __ _ _(_)_ __  __ _ \ \ \ \
( ( )\___ | '_ | '_| | '_ \/ _` | \ \ \ \
 \\/  ___)| |_)| | | | | || (_| |  ) ) ) )
  '  |____| .__|_| |_|_| |_\__, | / / / /
 =========|_|==============|___/=/_/_/_/
 :: Spring Boot ::                (v2.7.1)
```

# Convention over Configuration

- Convention over Configuration (programming by convention), is a software design paradigm that aims to reduce the number of decisions software developers have to make, with the benefits of simplicity without losing flexibility.
- Developers only need to specify the non-conforming parts of the application
- E.g., when we import a spring-boot-starter-web.jar, Spring Boot automatically imports Spring MVC dependencies and configures a built-in Tomcat container.

## Spring Boot Flow Architecture



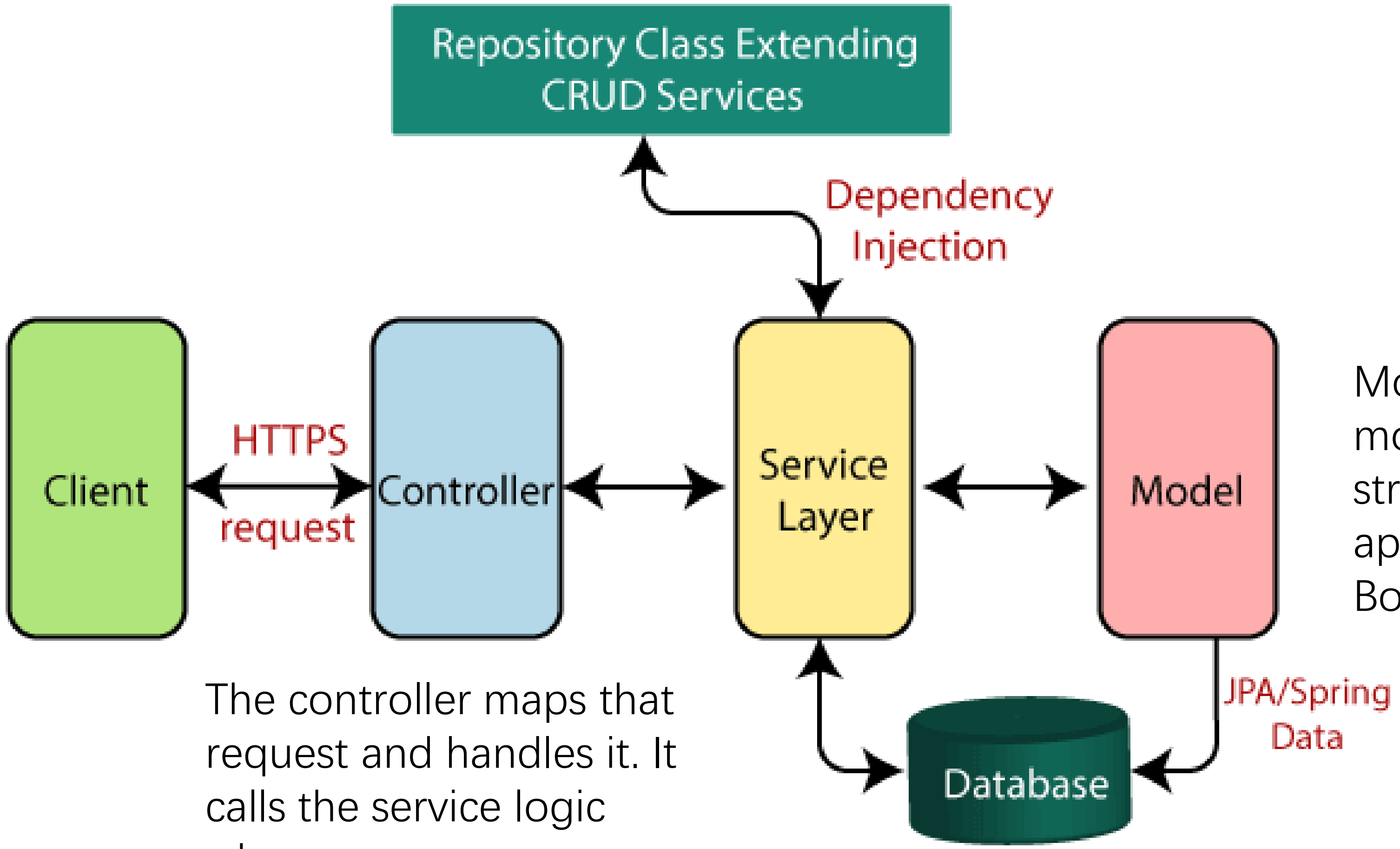
The client makes HTTP requests, which go to the controllers

The controller maps that request and handles it. It calls the service logic when necessary.

The service layer performs the business logic. It defines which functionalities you provide, how they are accessed, and what to pass and get in return

## Spring Boot Flow Architecture

The client makes HTTP requests, which go to the controllers



Model includes data model/entities/data structures used in the application, e.g., User, Book, Product, Account

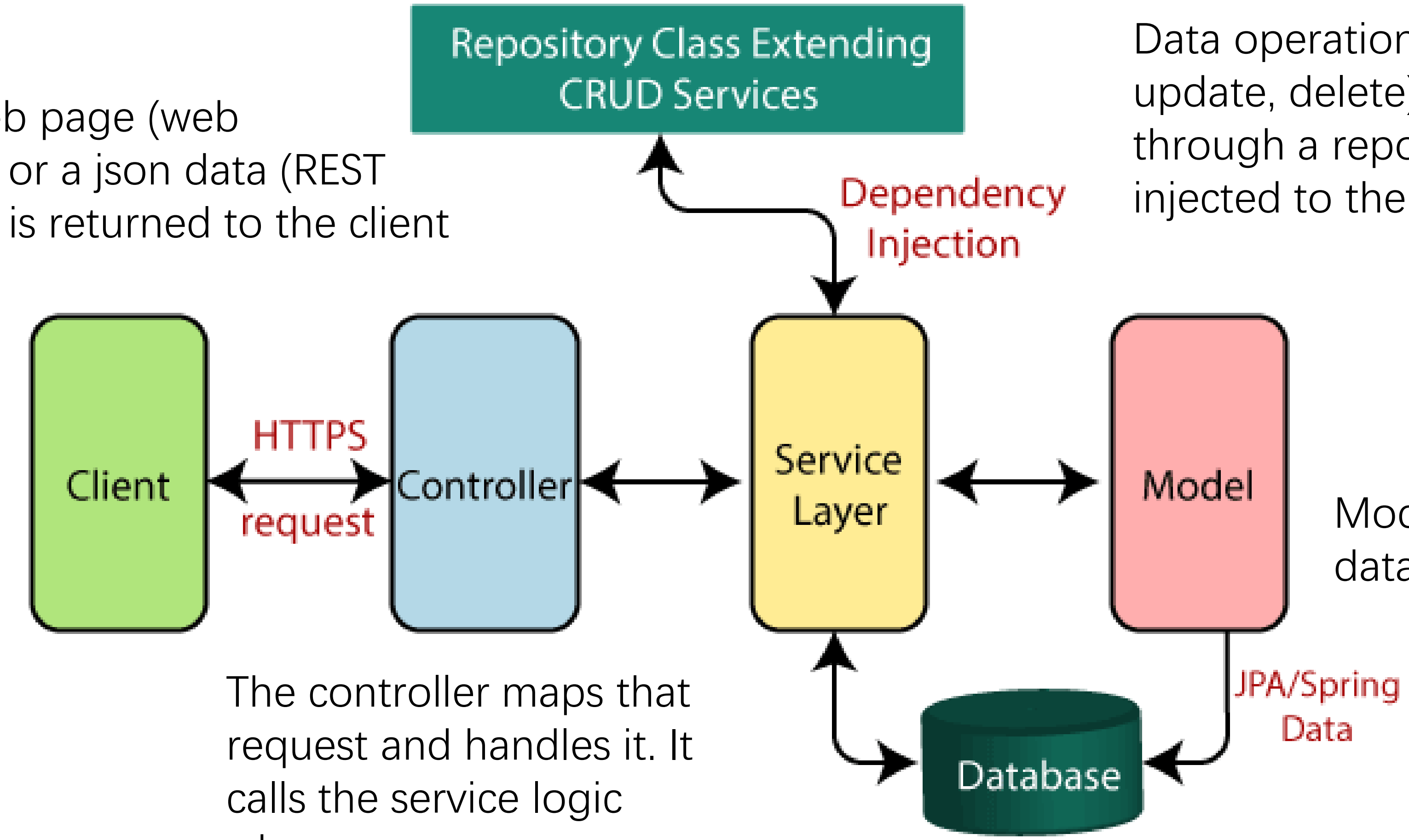
The controller maps that request and handles it. It calls the service logic when necessary.

# Spring Boot Flow Architecture

Finally, a web page (web application) or a json data (REST application) is returned to the client

Data operations (e.g., create, read, update, delete) are performed through a repository class, which is injected to the service class

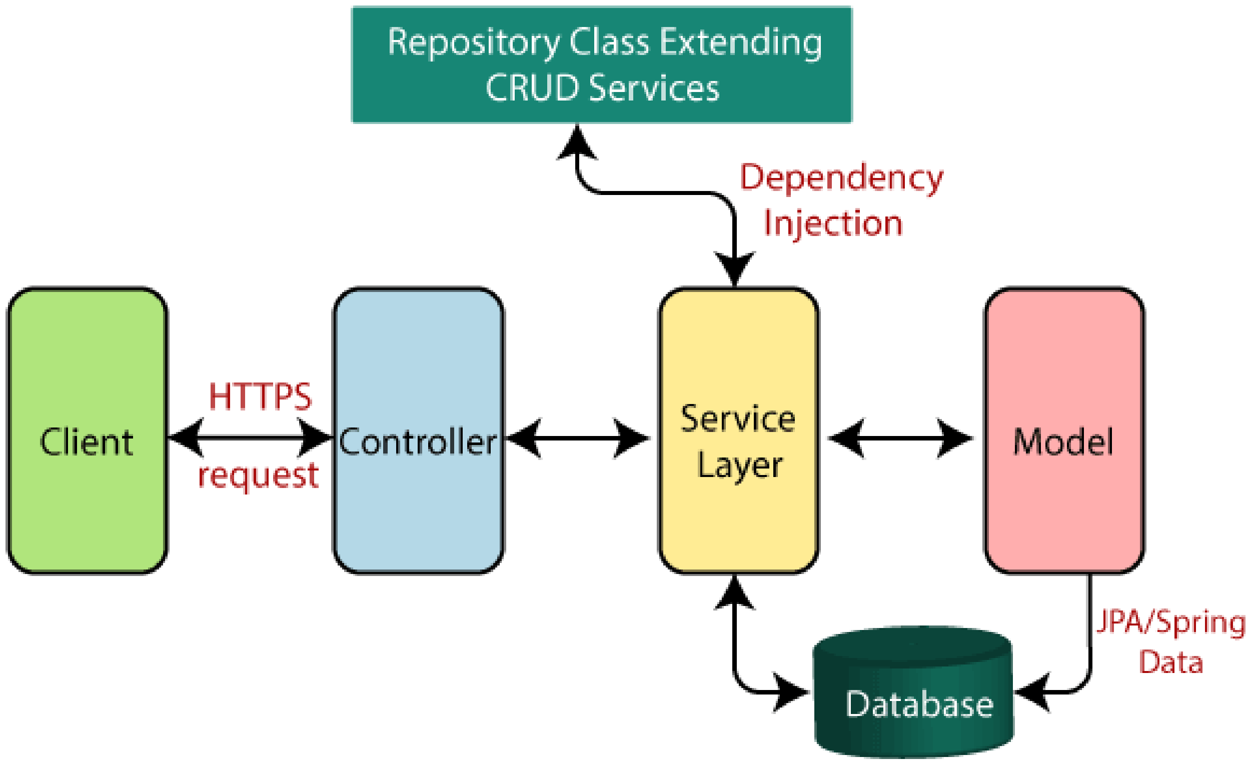
The client makes HTTP requests, which go to the controllers

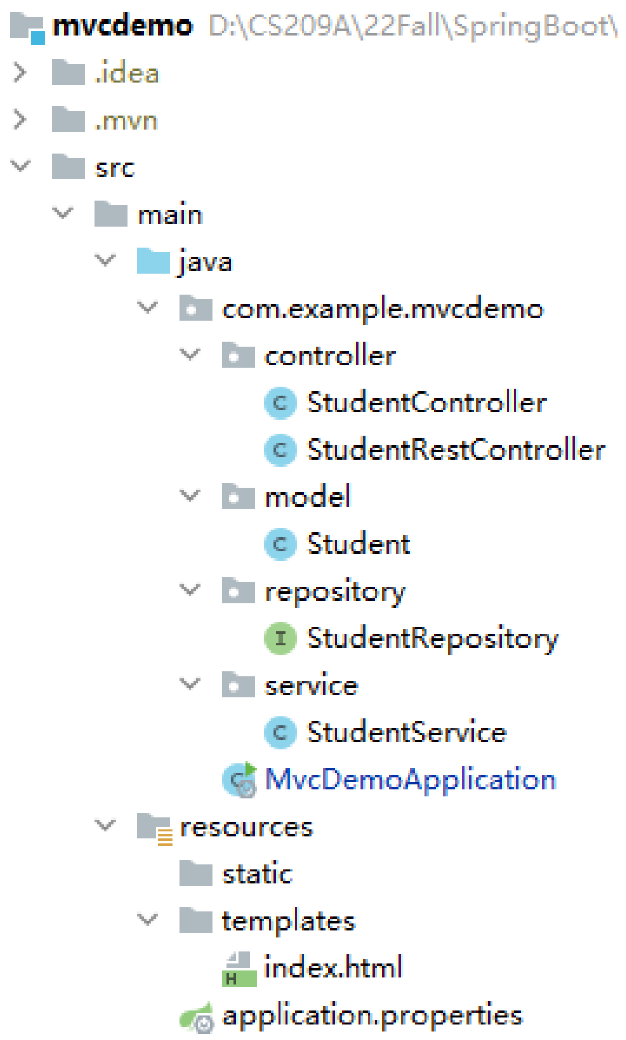


Model object is mapped to database by Spring Data JPA

The controller maps that request and handles it. It calls the service logic when necessary.

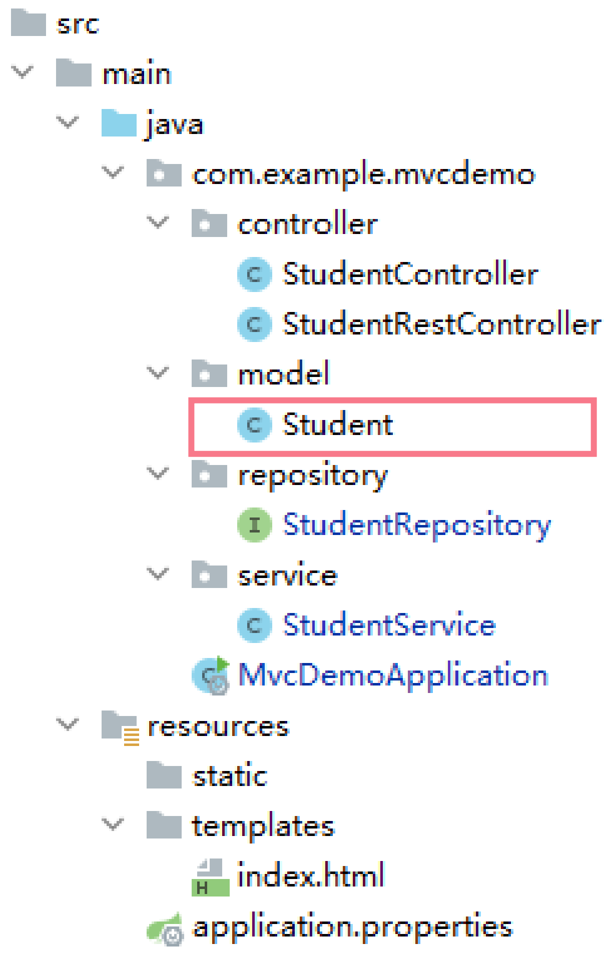
## A Simple Student Management Web Application



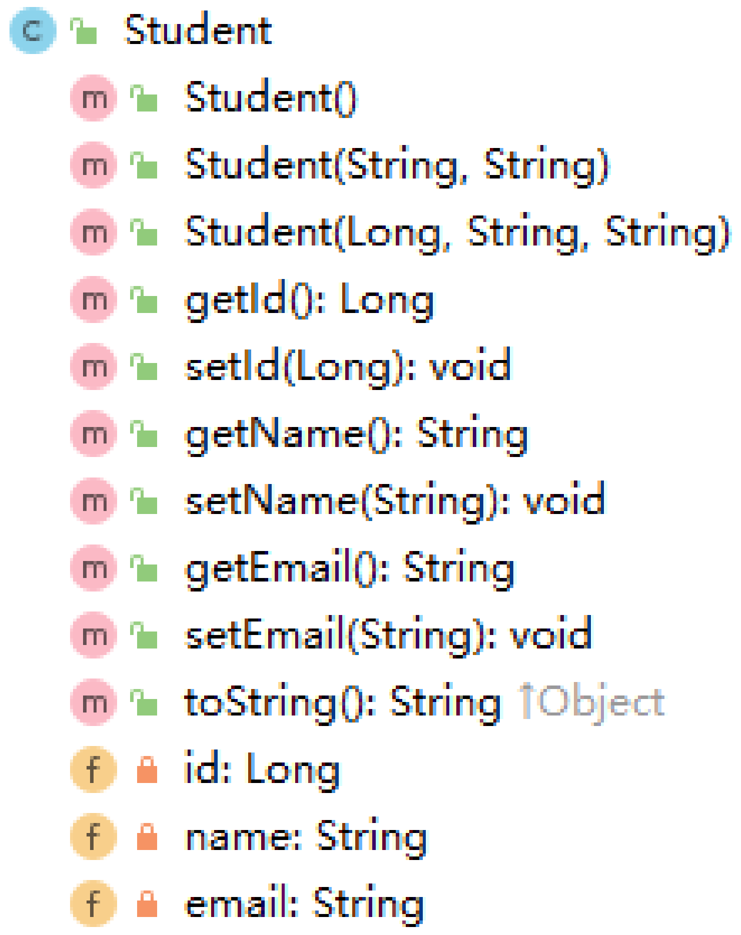


```
mvcdemo  D:\CS209A\22Fall\SpringBoot\
> .idea
> .mvn
v src
  v main
    v java
      v com.example.mvcdemo
        v controller
            StudentController
            StudentRestController
        v model
            Student
        v repository
            StudentRepository
        v service
            StudentService
          MvcDemoApplication
    v resources
        static
      v templates
          index.html
        application.properties
```

# Model



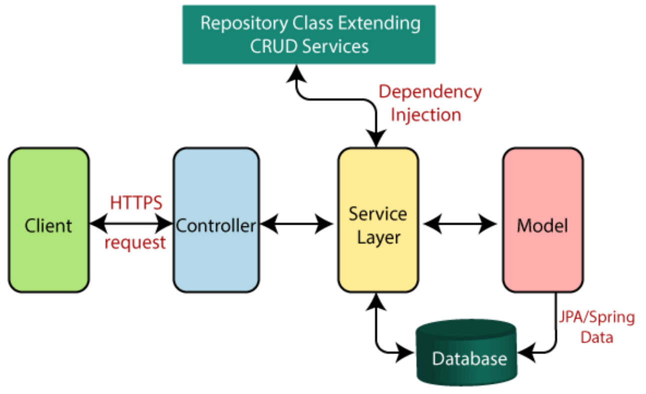
```
src
  main
    java
      com.example.mvcdemo
        controller
          StudentController
          StudentRestController
        model
          Student
        repository
          StudentRepository
        service
          StudentService
        MvcDemoApplication
    resources
      static
      templates
        index.html
      application.properties
```



```
Student
  Student()
  Student(String, String)
  Student(Long, String, String)
  getId(): Long
  setId(Long): void
  getName(): String
  setName(String): void
  getEmail(): String
  setEmail(String): void
  toString(): String ↑Object
  id: Long
  name: String
  email: String
```

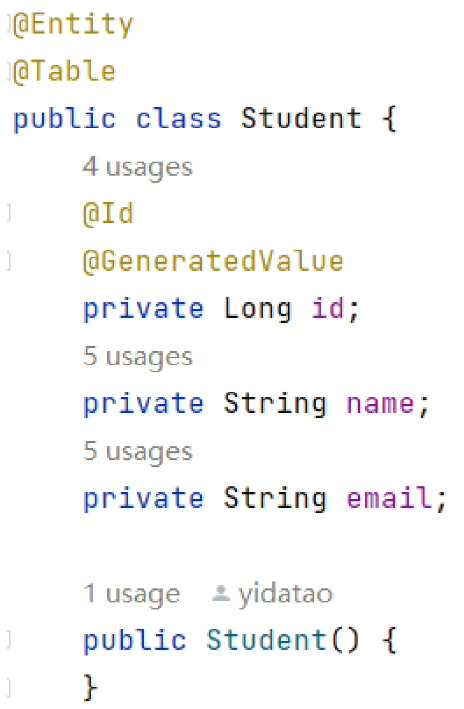
JavaBean: a POJO that conforms to certain conventions

- All properties are private
- Public setters and getters
- A public no-argument constructor

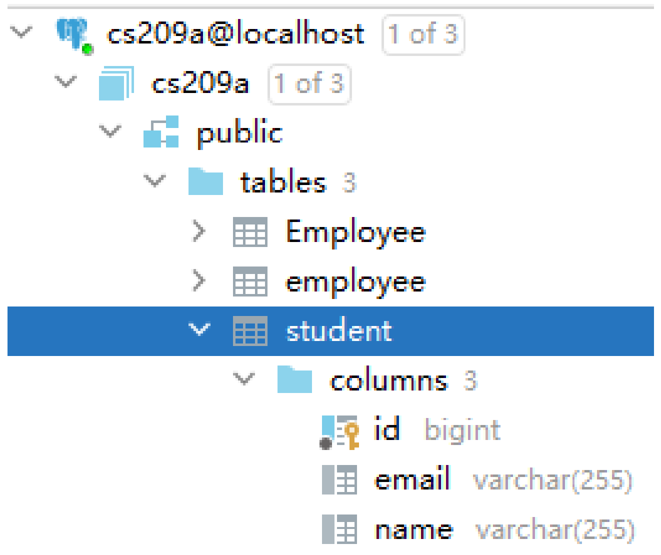


## Mapping Model Class to Database Table

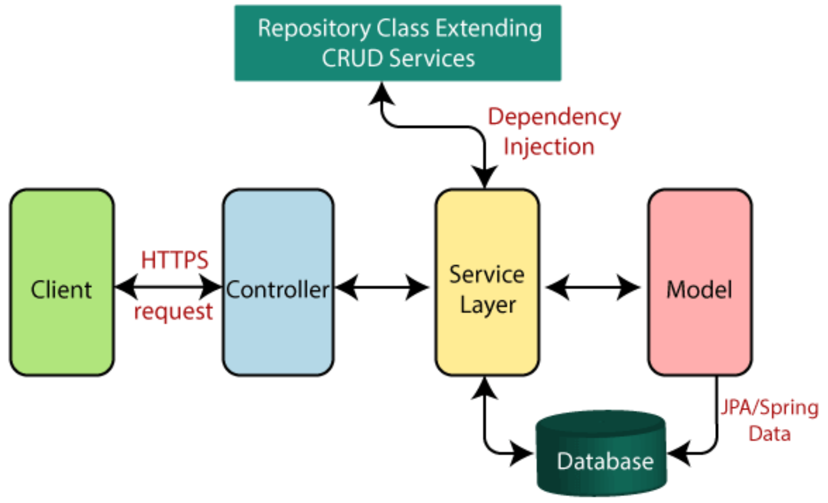
- `@Entity`: specifies that the class is an entity and is mapped to a database table
- `@Table`: specifies the name of the database table to be used for mapping (default is the class name)
- `@Id`: specifies the primary key of an entity
- `@GeneratedValue`: specifies the generation strategies for the values of primary keys (default: auto).



```
@Entity
@Table
public class Student {
    4 usages
    @Id
    @GeneratedValue
    private Long id;
    5 usages
    private String name;
    5 usages
    private String email;

    1 usage  yidatao
    public Student() {
    }
```

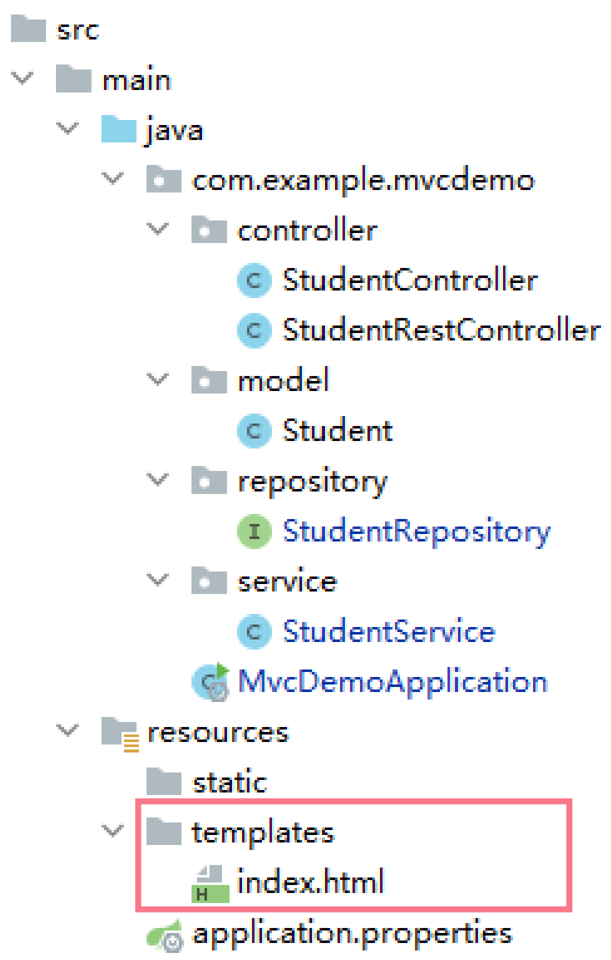


```
cs209a@localhost  1 of 3
  cs209a  1 of 3
    public
      tables  3
        Employee
        employee
        student
          columns  3
            id  bigint
            email  varchar(255)
            name  varchar(255)
```

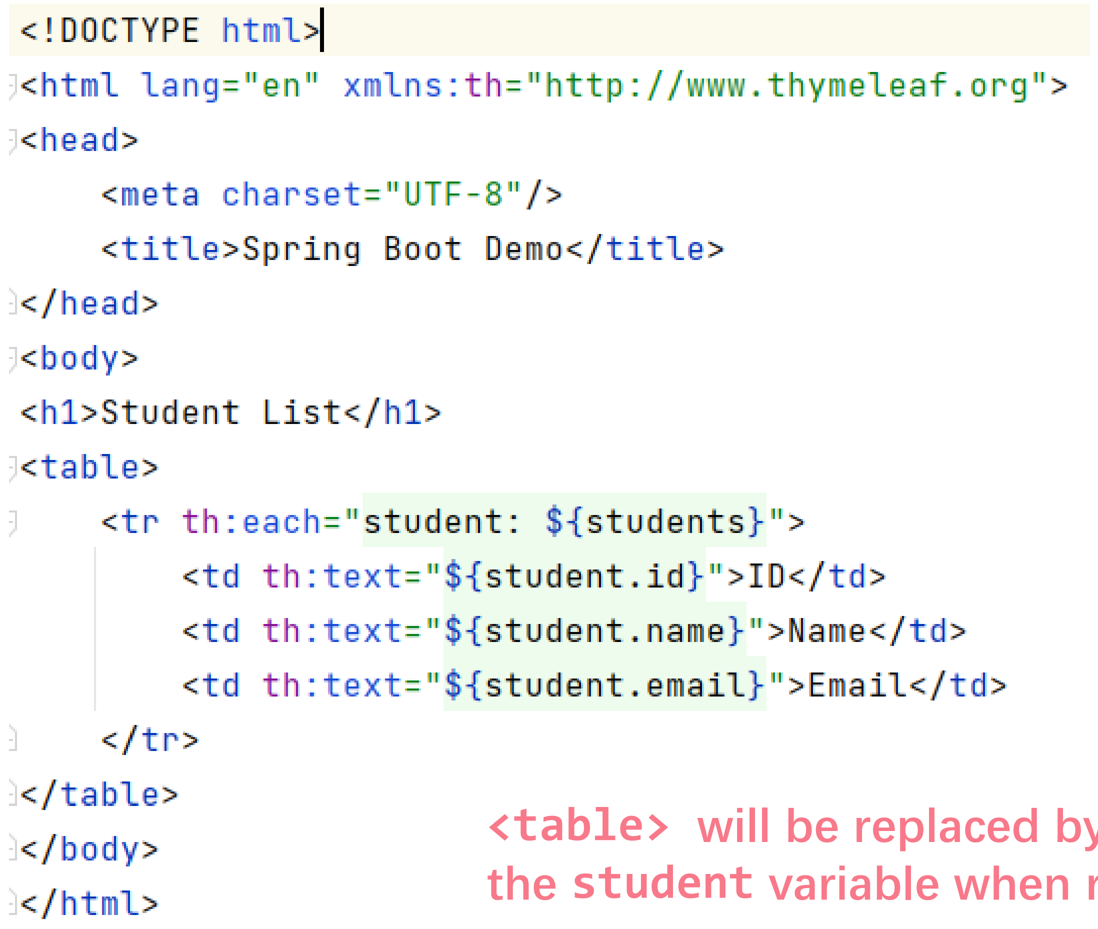


## View

A Thymeleaf template that contain HTML code with Thymeleaf-specific syntax (th:text, th:each, etc.)



```
src
  main
    java
      com.example.mvcdemo
        controller
          StudentController
          StudentRestController
        model
          Student
        repository
          StudentRepository
        service
          StudentService
        MvcDemoApplication
    resources
      static
      templates
        index.html
      application.properties
```

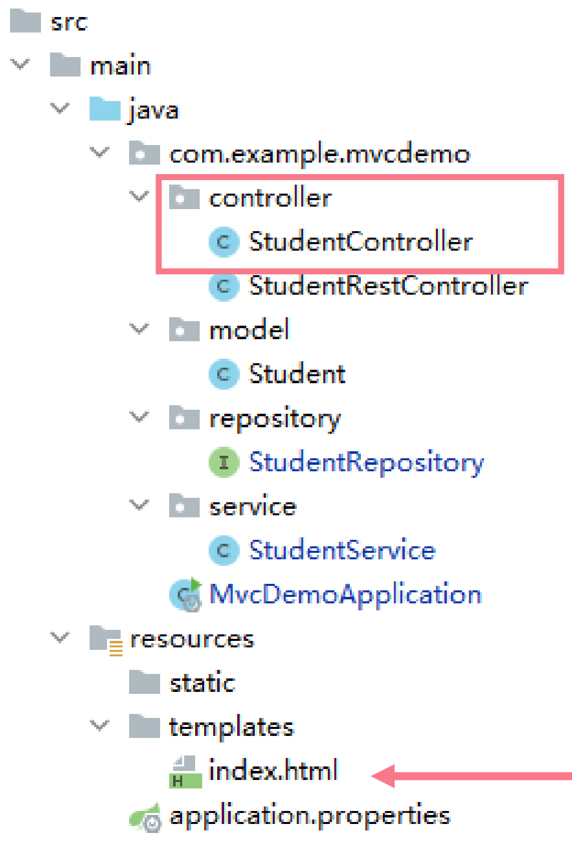


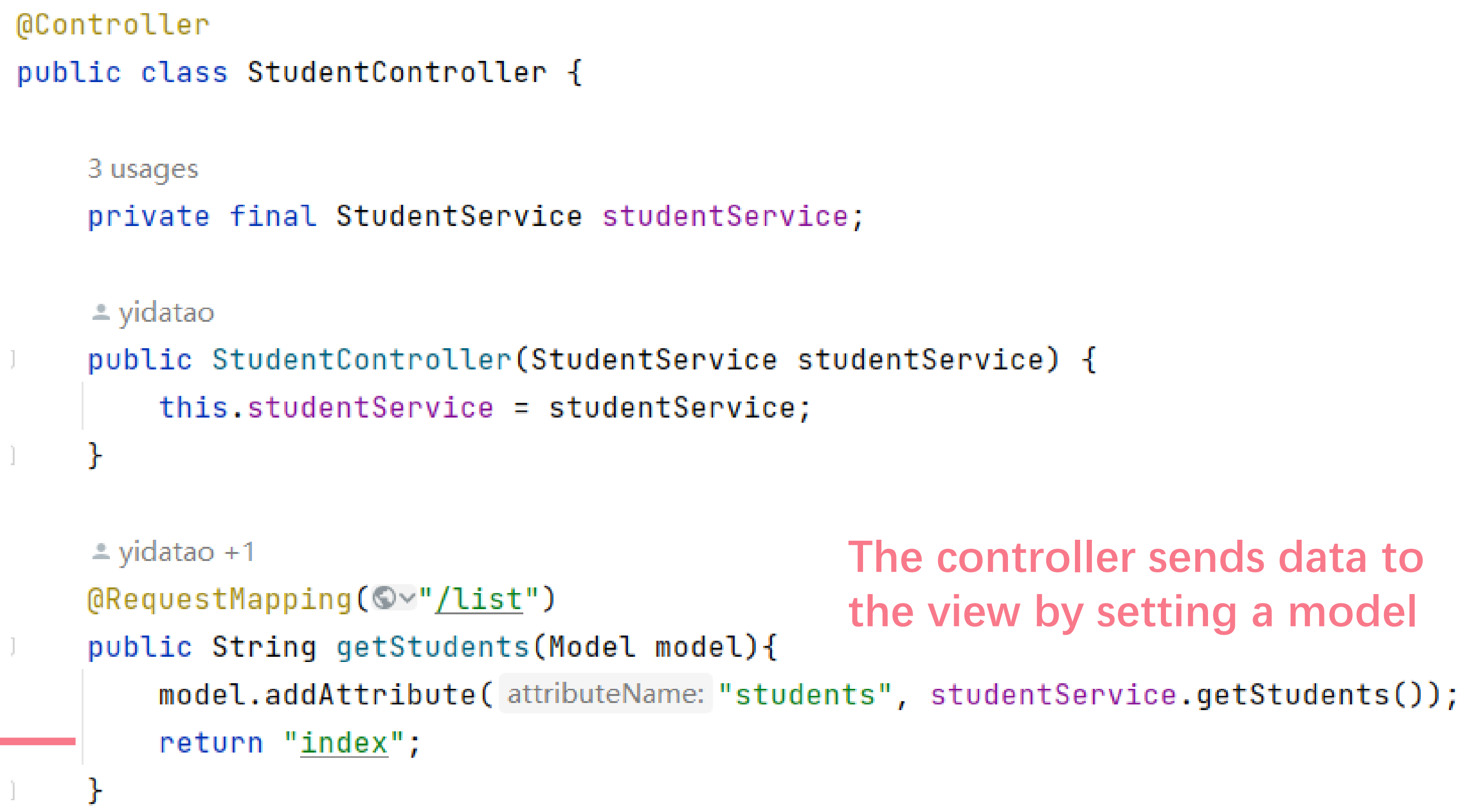
```
<!DOCTYPE html>
<html lang="en" xmlns:th="http://www.thymeleaf.org">
<head>
    <meta charset="UTF-8"/>
    <title>Spring Boot Demo</title>
</head>
<body>
<h1>Student List</h1>
<table>
    <tr th:each="student: ${students}">
        <td th:text="${student.id}">ID</td>
        <td th:text="${student.name}">Name</td>
        <td th:text="${student.email}">Email</td>
    </tr>
</table>
</body>
</html>
```

`<table>` will be replaced by values of the `student` variable when rendered

# Controller

`@Controller` is a class-level annotation that marks a class as a web request handler. It is mostly used with `@RequestMapping` annotation.



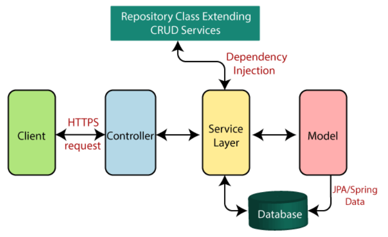


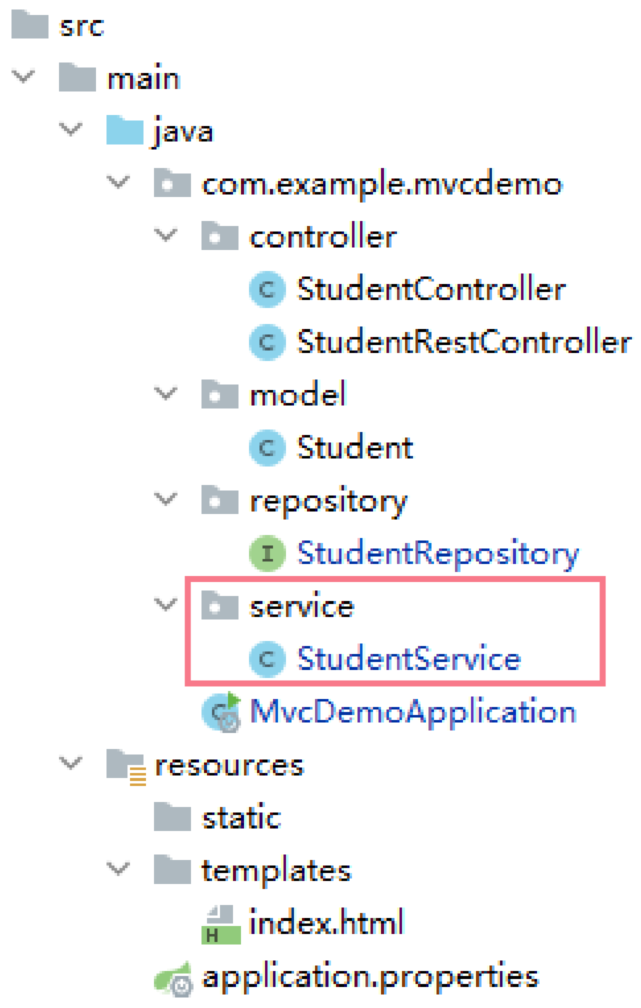
```
@Controller
public class StudentController {

    3 usages
    private final StudentService studentService;

    yidatao
    public StudentController(StudentService studentService) {
        this.studentService = studentService;
    }

    yidatao +1
    @RequestMapping("/list")
    public String getStudents(Model model){
        model.addAttribute( attributeName: "students", studentService.getStudents());
        return "index";
    }
```

The controller sends data to the view by setting a model

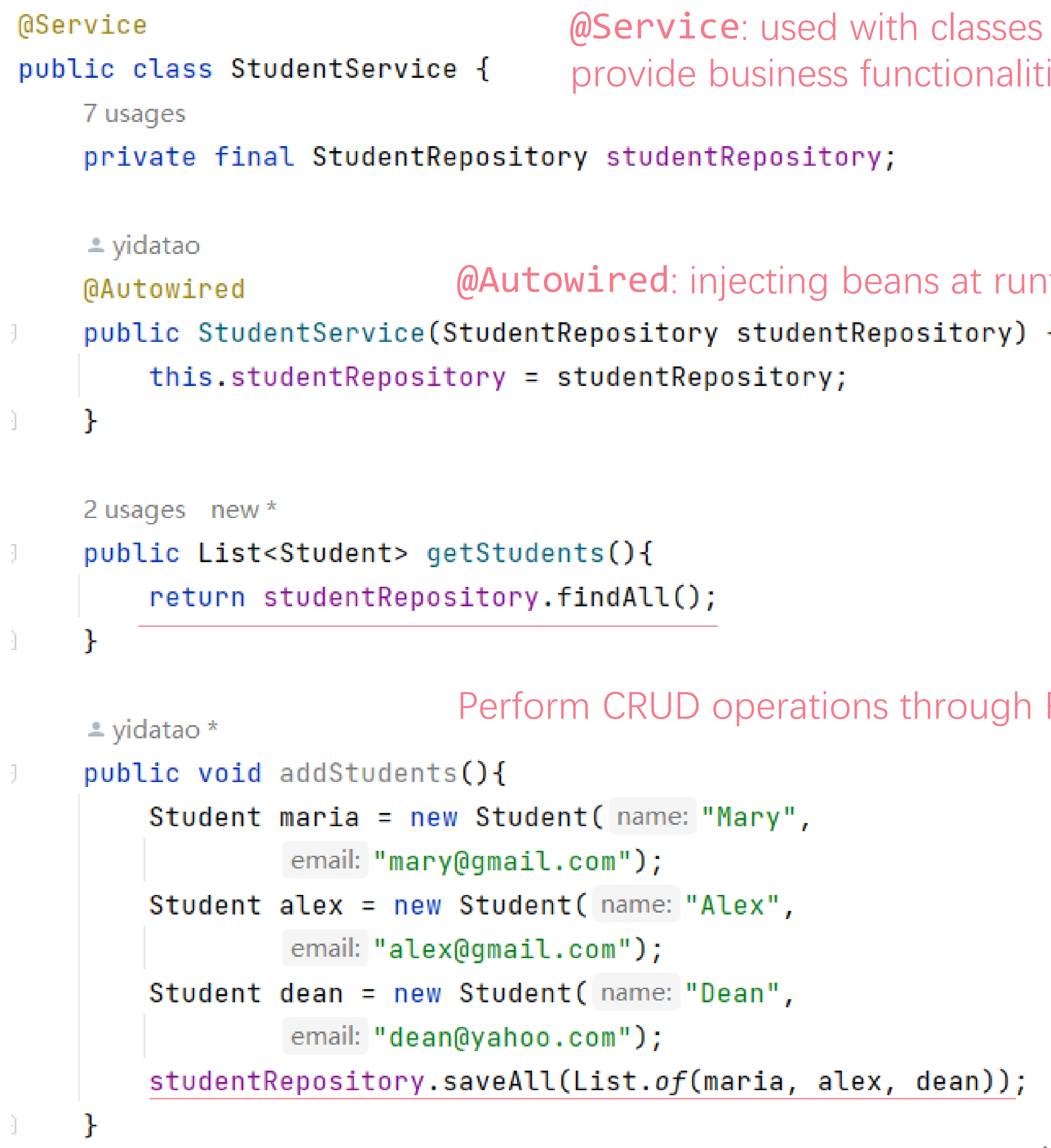
When a user accesses the /list URL, Thymeleaf will process the index.html template, replace the placeholders (e.g., ${students}) with actual values, and render the final HTML to be sent to the browser.

# Service





```
src
  main
    java
      com.example.mvcdemo
        controller
          StudentController
          StudentRestController
        model
          Student
        repository
          StudentRepository
        service
          StudentService
        MvcDemoApplication
    resources
      static
      templates
        index.html
      application.properties
```



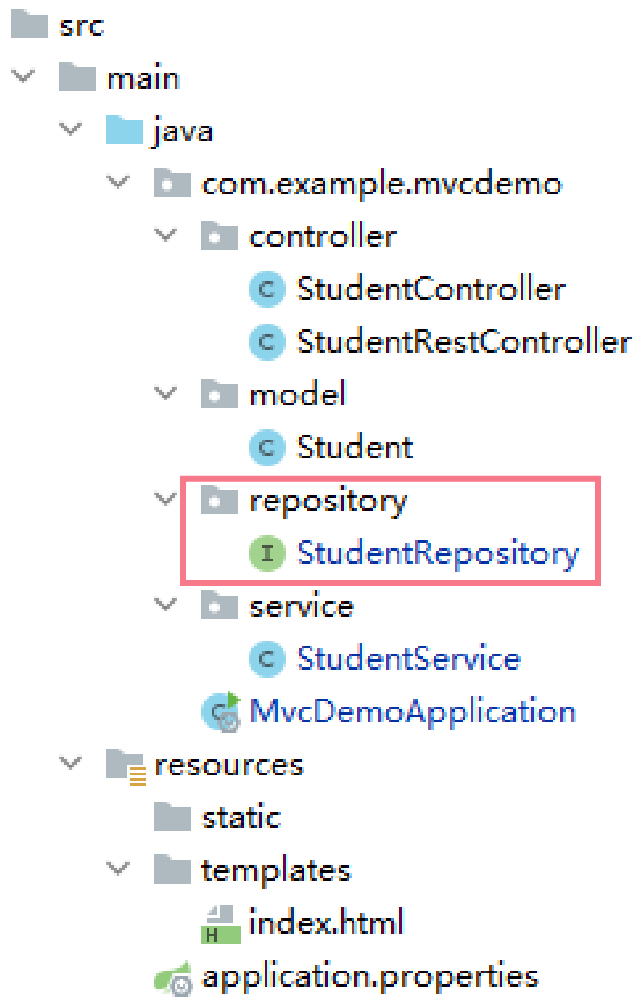
```
@Service
public class StudentService {
    7 usages
    private final StudentRepository studentRepository;

    yidatao
    @Autowired
    public StudentService(StudentRepository studentRepository) {
        this.studentRepository = studentRepository;
    }

    2 usages   new *
    public List<Student> getStudents(){
        return studentRepository.findAll();
    }

    yidatao *
    public void addStudents(){
        Student maria = new Student( name: "Mary",
                 email: "mary@gmail.com");
        Student alex = new Student( name: "Alex",
                 email: "alex@gmail.com");
        Student dean = new Student( name: "Dean",
                 email: "dean@yahoo.com");
        studentRepository.saveAll(List.of(maria, alex, dean));
    }
```

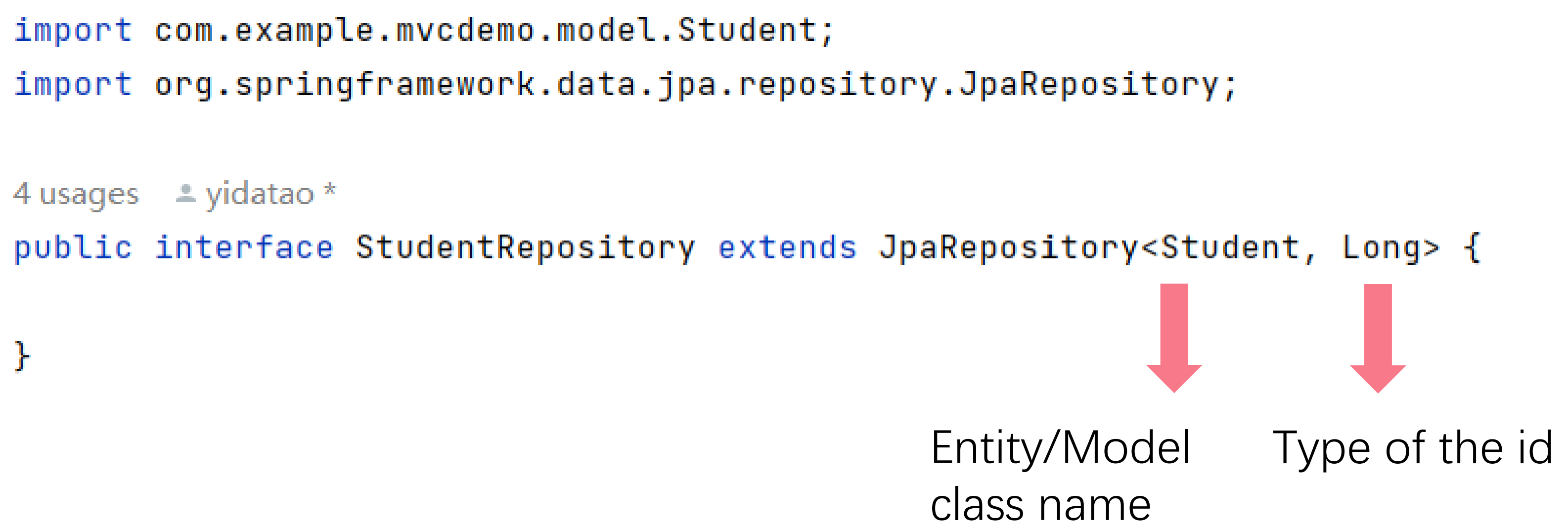
`@Service`: used with classes that provide business functionalities.

`@Autowired`: injecting beans at runtime

Perform CRUD operations through Repository

# Repository

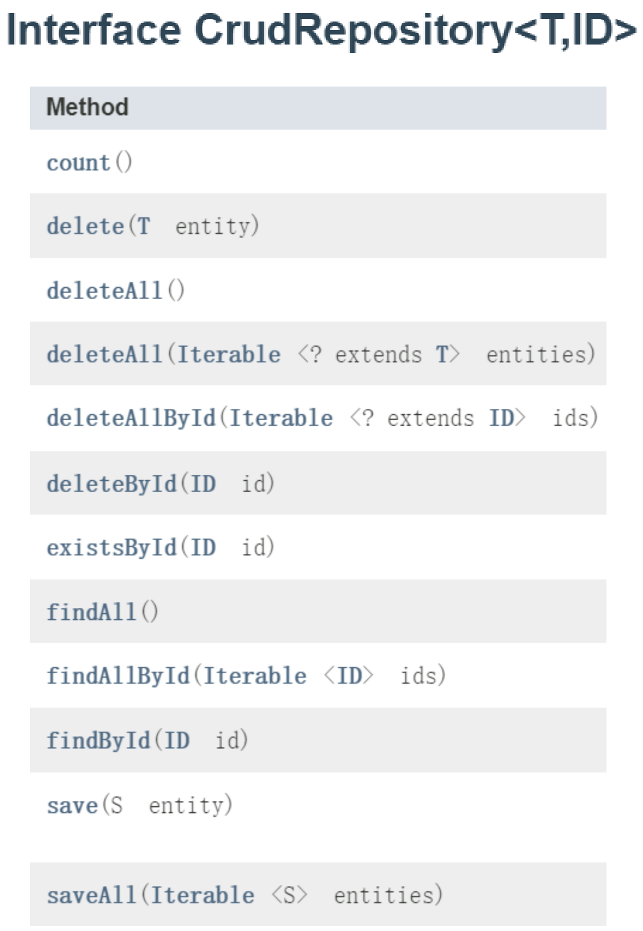

```
src
  main
    java
      com.example.mvcdemo
        controller
          StudentController
          StudentRestController
        model
          Student
        repository
          StudentRepository
        service
          StudentService
        MvcDemoApplication
    resources
      static
      templates
        index.html
      application.properties
```


```
import com.example.mvcdemo.model.Student;
import org.springframework.data.jpa.repository.JpaRepository;

4 usages   yidatao *
public interface StudentRepository extends JpaRepository<Student, Long> {

}
```

A `JpaRepository` interface defines basic methods for performing CRUD operations, sorting and paginating data.

## Repository

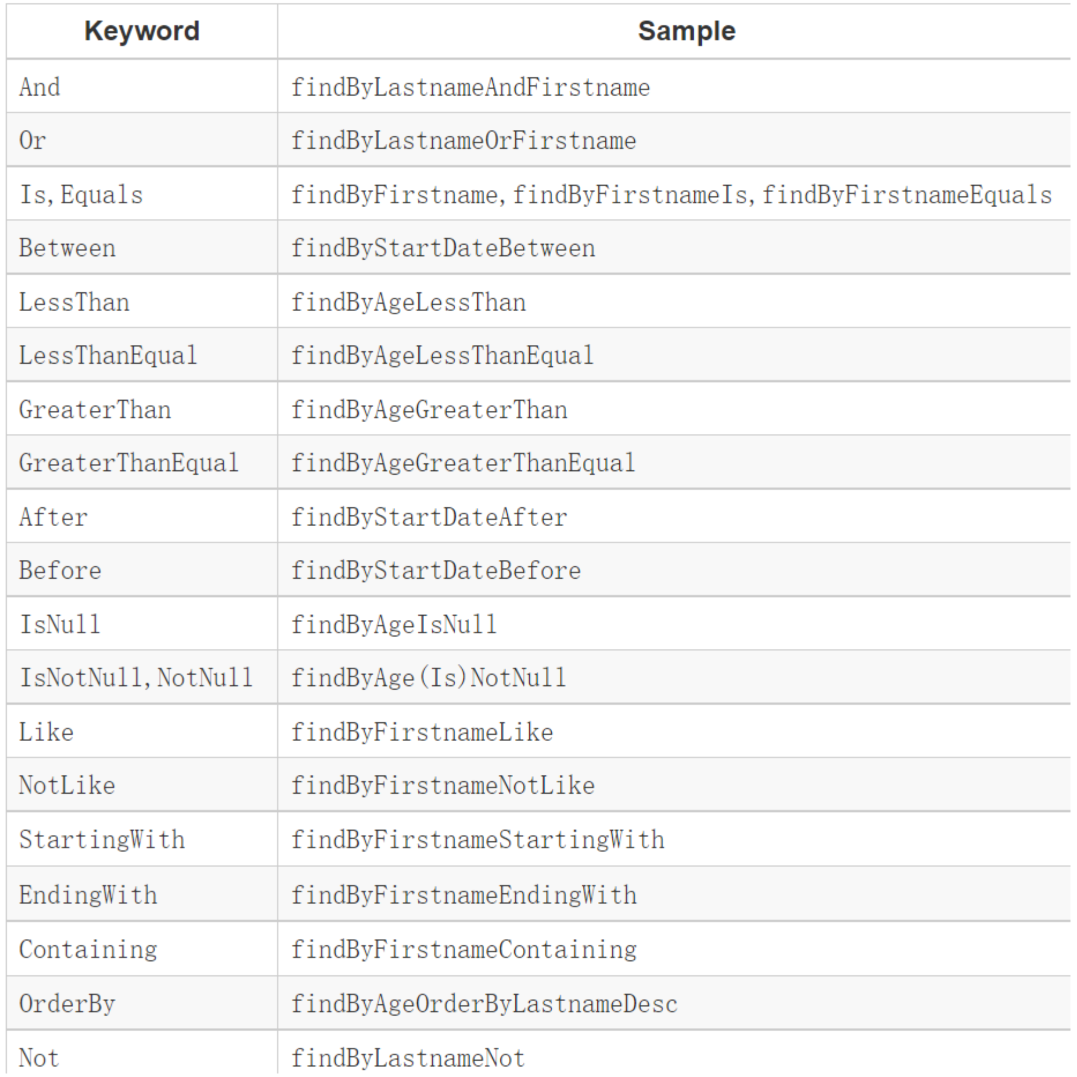
- A `JpaRepository` defines basic methods for performing CRUD operations, sorting and paginating data.
- To uses these methods, developers only need to extend specific `JpaRepository` for each domain/model entity (i.e., `Student`) in the application.
- Developers don't need to implement these methods. Spring Data JPA implements them automatically (by using Hibernate as the default implementation)


Interface CrudRepository<T,ID>

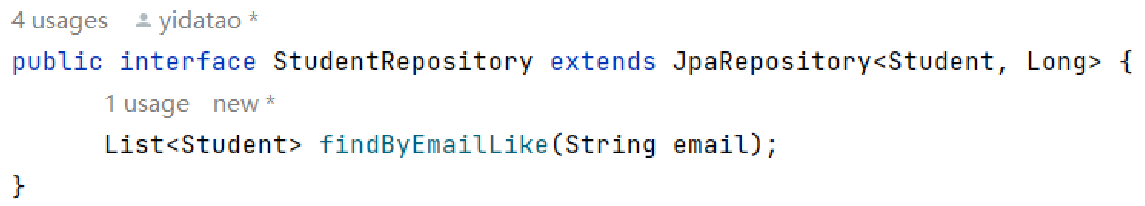
| Method |
|---|
| `count()` |
| `delete(T entity)` |
| `deleteAll()` |
| `deleteAll(Iterable <? extends T> entities)` |
| `deleteAllById(Iterable <? extends ID> ids)` |
| `deleteById(ID id)` |
| `existsById(ID id)` |
| `findAll()` |
| `findAllById(Iterable <ID> ids)` |
| `findById(ID id)` |
| `save(S entity)` |
| `saveAll(Iterable <S> entities)` |

## Repository

- We could also define customized finder methods, following specific naming conventions, e.g.,
    - Method prefixes should be: findBy, queryBy, countBy……
    - Certain keywords are allowed
- Again, we don't need to actually implement them. Spring will generate the implementation automatically

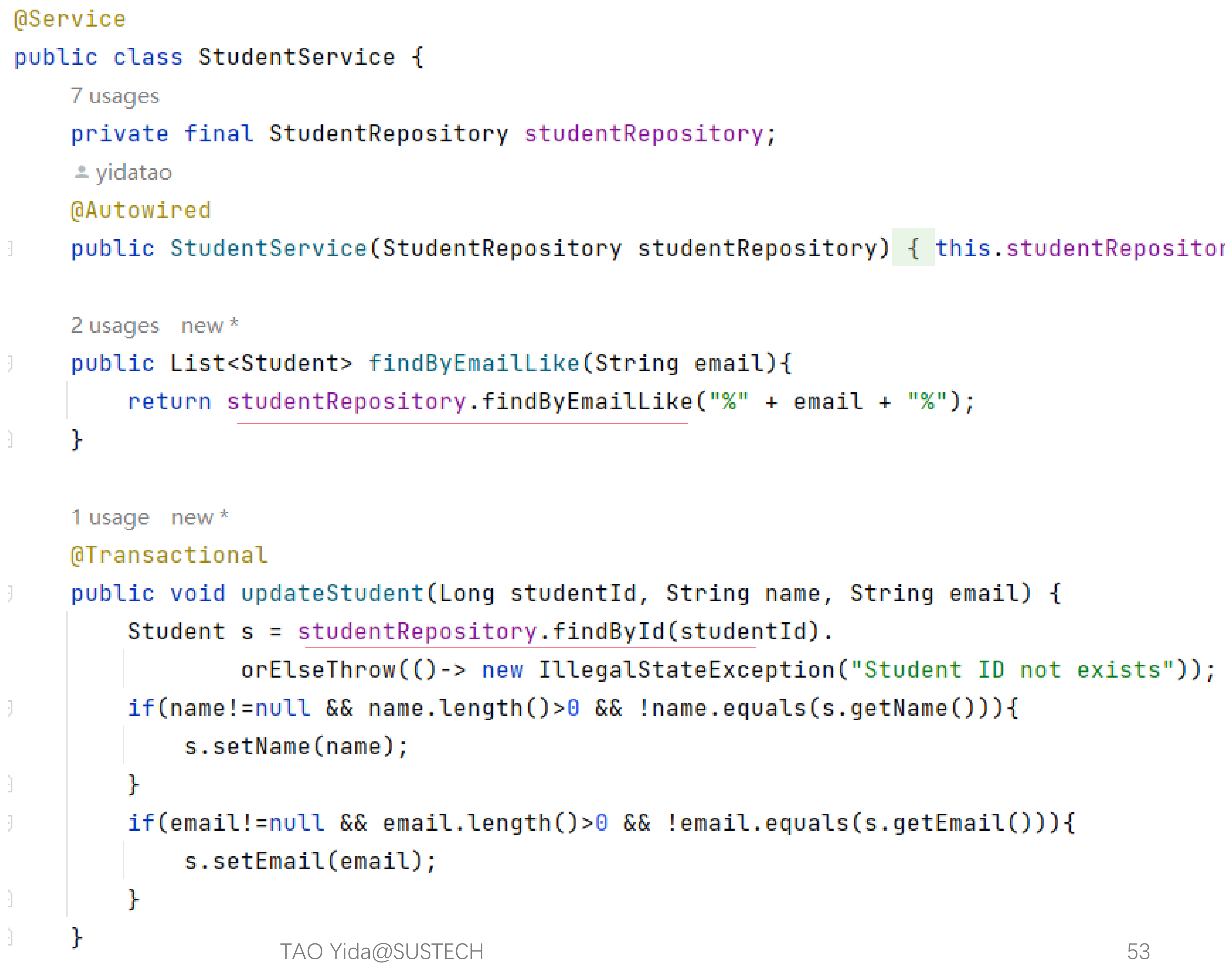


| Keyword | Sample |
|---|---|
| And | findByLastnameAndFirstname |
| Or | findByLastnameOrFirstname |
| Is, Equals | findByFirstname, findByFirstnameIs, findByFirstnameEquals |
| Between | findByStartDateBetween |
| LessThan | findByAgeLessThan |
| LessThanEqual | findByAgeLessThanEqual |
| GreaterThan | findByAgeGreaterThan |
| GreaterThanEqual | findByAgeGreaterThanEqual |
| After | findByStartDateAfter |
| Before | findByStartDateBefore |
| IsNull | findByAgeIsNull |
| IsNotNull, NotNull | findByAge(Is)NotNull |
| Like | findByFirstnameLike |
| NotLike | findByFirstnameNotLike |
| StartingWith | findByFirstnameStartingWith |
| EndingWith | findByFirstnameEndingWith |
| Containing | findByFirstnameContaining |
| OrderBy | findByAgeOrderByLastnameDesc |
| Not | findByLastnameNot |



```
4 usages  yidatao *
public interface StudentRepository extends JpaRepository<Student, Long> {
    1 usage  new *
    List<Student> findByEmailLike(String email);
}
```

## Repository

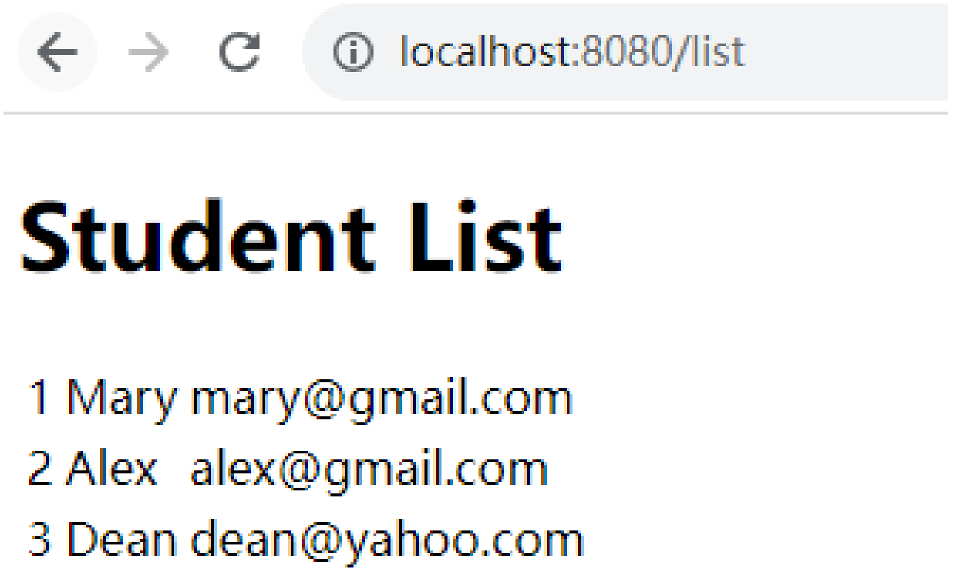


```
@Service
public class StudentService {
    7 usages
    private final StudentRepository studentRepository;
    yidatao
    @Autowired
    public StudentService(StudentRepository studentRepository) { this.studentRepositor

    2 usages   new *
    public List<Student> findByEmailLike(String email){
        return studentRepository.findByEmailLike("%" + email + "%");
    }

    1 usage   new *
    @Transactional
    public void updateStudent(Long studentId, String name, String email) {
        Student s = studentRepository.findById(studentId).
                orElseThrow(()-> new IllegalStateException("Student ID not exists"));
        if(name!=null && name.length()>0 && !name.equals(s.getName())){
            s.setName(name);
        }
        if(email!=null && email.length()>0 && !email.equals(s.getEmail())){
            s.setEmail(email);
        }
    }
```

## Bootstrap

Spring boot’s **`CommandLineRunner`** interface is used to run a code block only once in application’s lifetime – after application is initialized.

```java
@SpringBootApplication
public class MvcDemoApplication {
    yidatao
    public static void main(String[] args) {
        SpringApplication.run(MvcDemoApplication.class, args);
    }

    yidatao
    @Bean
    public CommandLineRunner commandLineRunner(StudentService service){
        return args -> {
            service.addStudents();
        };
    }

}
```



# Student List

1 Mary mary@gmail.com

2 Alex alex@gmail.com

3 Dean dean@yahoo.com

## Building a RESTful Web Service

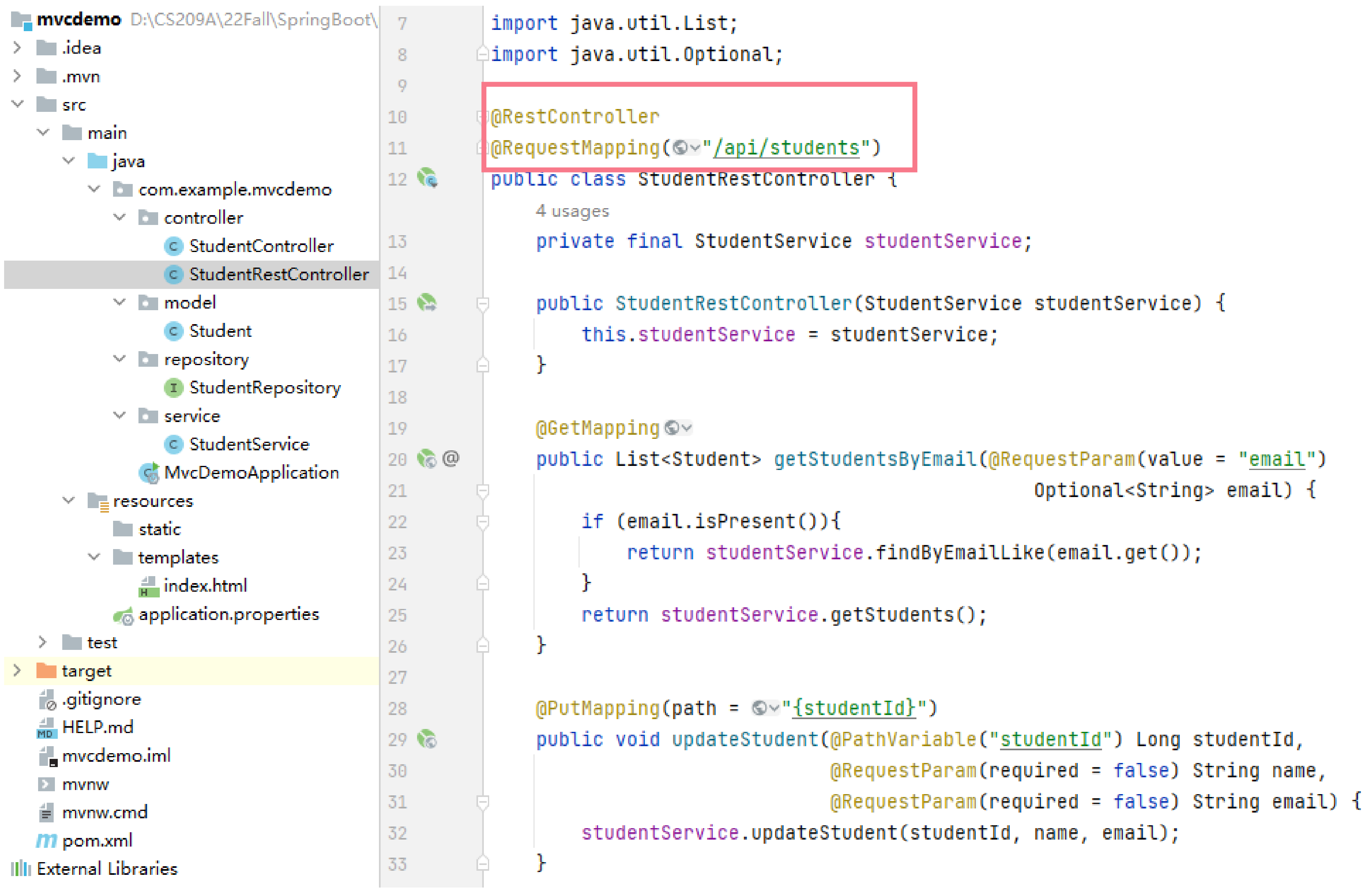
- Key difference between an MVC controller and RESTful controller: how HTTP response body is created
  - **MVC controller**: relies on a view technology to return data in HTML
  - **REST controller**: returns data as object, which is written directly to the HTTP response as JSON

- Spring Initializer: `Spring Web` is sufficient

# RestController

`@RestController`: marks the class as a controller where every method returns a domain object instead of a view (shorthand for @Controller+@ResponseBody)

`@RequestMapping`: defines a base URL for all the REST APIs created in this controller

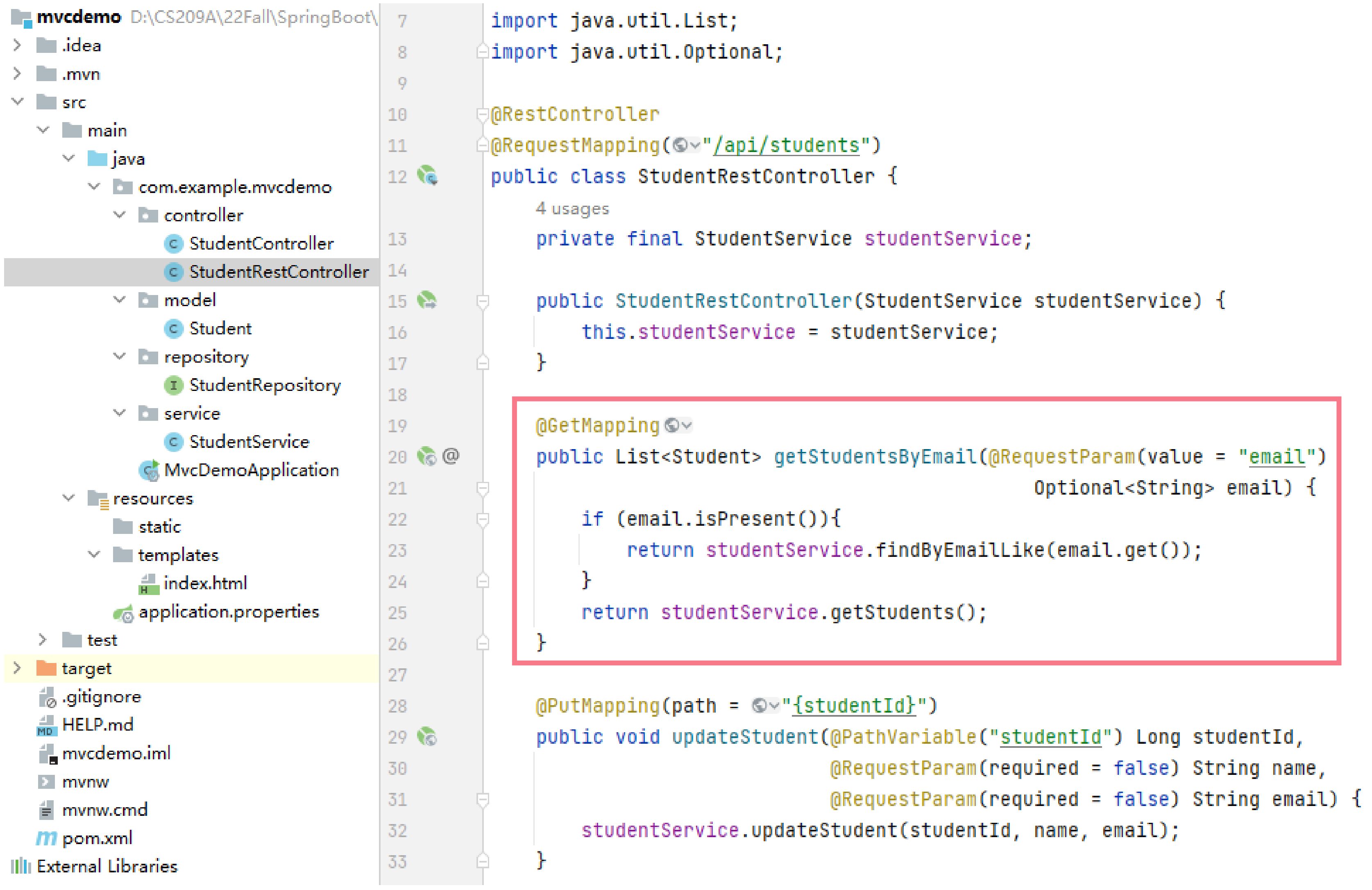


```java
import java.util.List;
import java.util.Optional;

@RestController
@RequestMapping("/api/students")
public class StudentRestController {
    4 usages
    private final StudentService studentService;

    public StudentRestController(StudentService studentService) {
        this.studentService = studentService;
    }

    @GetMapping
    public List<Student> getStudentsByEmail(@RequestParam(value = "email")
                                            Optional<String> email) {
        if (email.isPresent()){
            return studentService.findByEmailLike(email.get());
        }
        return studentService.getStudents();
    }

    @PutMapping(path = "{studentId}")
    public void updateStudent(@PathVariable("studentId") Long studentId,
                              @RequestParam(required = false) String name,
                              @RequestParam(required = false) String email) {
        studentService.updateStudent(studentId, name, email);
    }
```

# RestController

**@GetMapping**: ensures that HTTP GET requests to `api/students` are mapped to the corresponding method.

**@RequestParam**: binds the value of the query string parameter `email` into the `email` parameter of this method



```
mvcdemo D:\CS209A\22Fall\SpringBoot\
> .idea
> .mvn
v src
  v main
    v java
      v com.example.mvcdemo
        v controller
            StudentController
            StudentRestController
        v model
            Student
        v repository
            StudentRepository
        v service
            StudentService
          MvcDemoApplication
    v resources
        static
      v templates
          index.html
        application.properties
  > test
> target
  .gitignore
  HELP.md
  mvcdemo.iml
  mvnw
  mvnw.cmd
  pom.xml
External Libraries
```

```java
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import java.util.Optional;

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        if (email.isPresent()){
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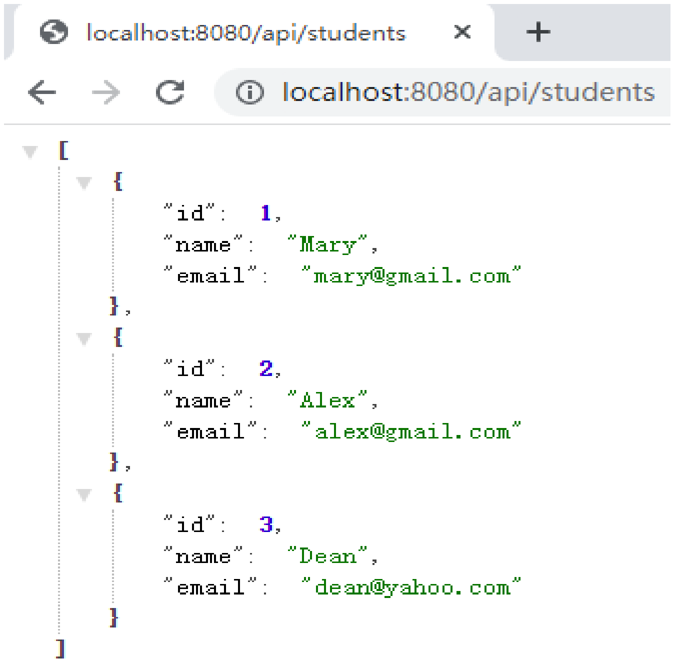
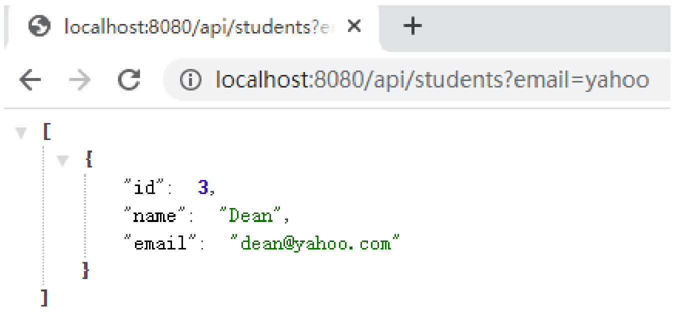
        }
        return studentService.getStudents();
    }

    @PutMapping(path = "{studentId}")
    public void updateStudent(@PathVariable("studentId") Long studentId,
                              @RequestParam(required = false) String name,
                              @RequestParam(required = false) String email) {
        studentService.updateStudent(studentId, name, email);
    }
```



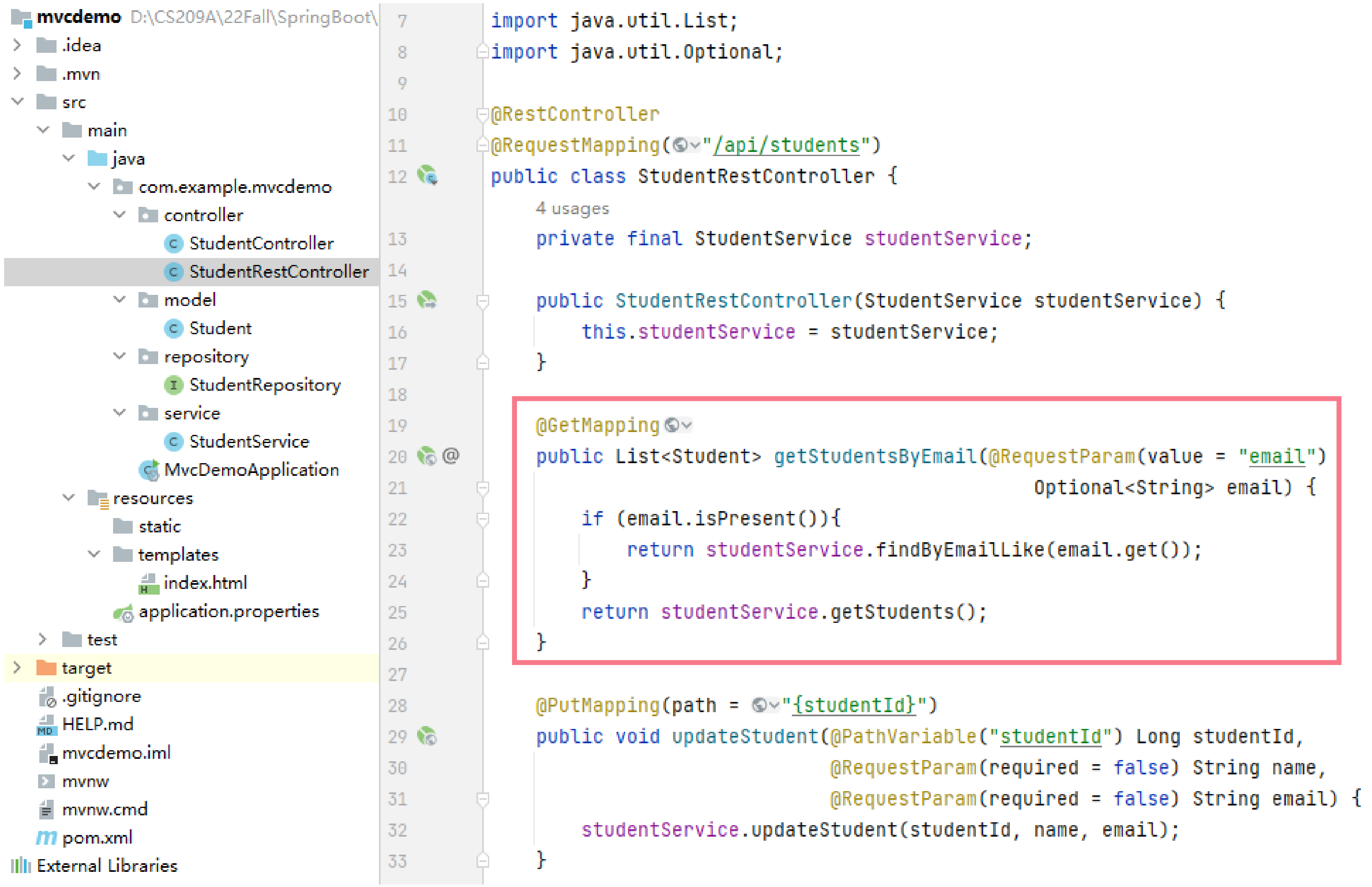
localhost:8080/api/students

```
[
  {
    "id": 1,
    "name": "Mary",
    "email": "mary@gmail.com"
  },
  {
    "id": 2,
    "name": "Alex",
    "email": "alex@gmail.com"
  },
  {
    "id": 3,
    "name": "Dean",
    "email": "dean@yahoo.com"
  }
]
```



localhost:8080/api/students?email=yahoo

```
[
  {
    "id": 3,
    "name": "Dean",
    "email": "dean@yahoo.com"
  }
]
```



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            StudentRepository
          service
            StudentService
          MvcDemoApplication
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```

```java
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import java.util.Optional;

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public class StudentRestController {
    4 usages
    private final StudentService studentService;

    public StudentRestController(StudentService studentService) {
        this.studentService = studentService;
    }

    @GetMapping
    public List<Student> getStudentsByEmail(@RequestParam(value = "email")
                                            Optional<String> email) {
        if (email.isPresent()){
            return studentService.findByEmailLike(email.get());
        }
        return studentService.getStudents();
    }

    @PutMapping(path = "{studentId}")
    public void updateStudent(@PathVariable("studentId") Long studentId,
                              @RequestParam(required = false) String name,
                              @RequestParam(required = false) String email) {
        studentService.updateStudent(studentId, name, email);
    }
```
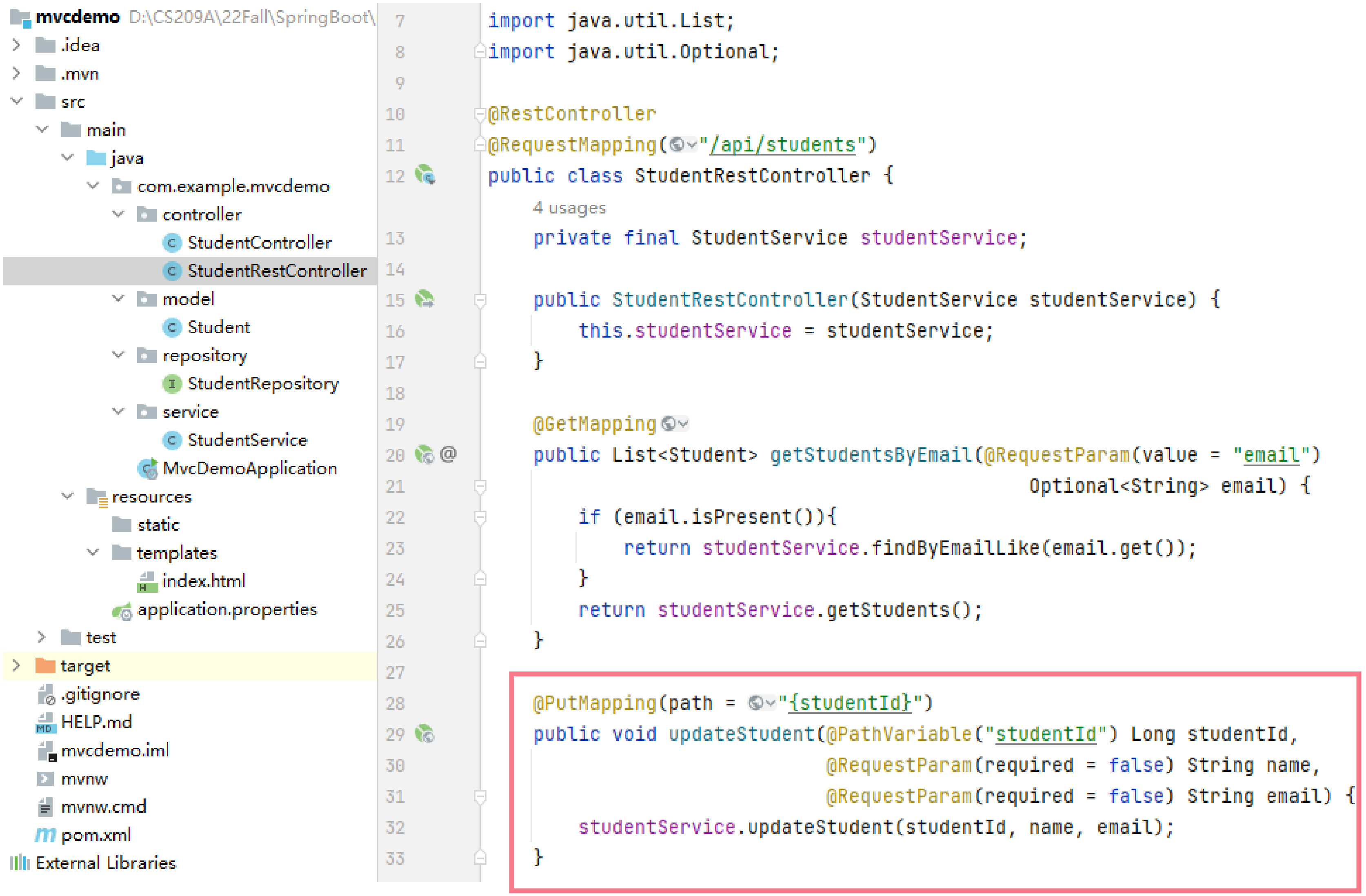

# RestController

`@PutMapping`: maps HTTP PUT requests onto specific handler methods (shortcut for `@RequestMapping(method = RequestMethod.PUT)`)

`@PathVariable`: extracts values from the URI path and binds to the `studentId` parameter



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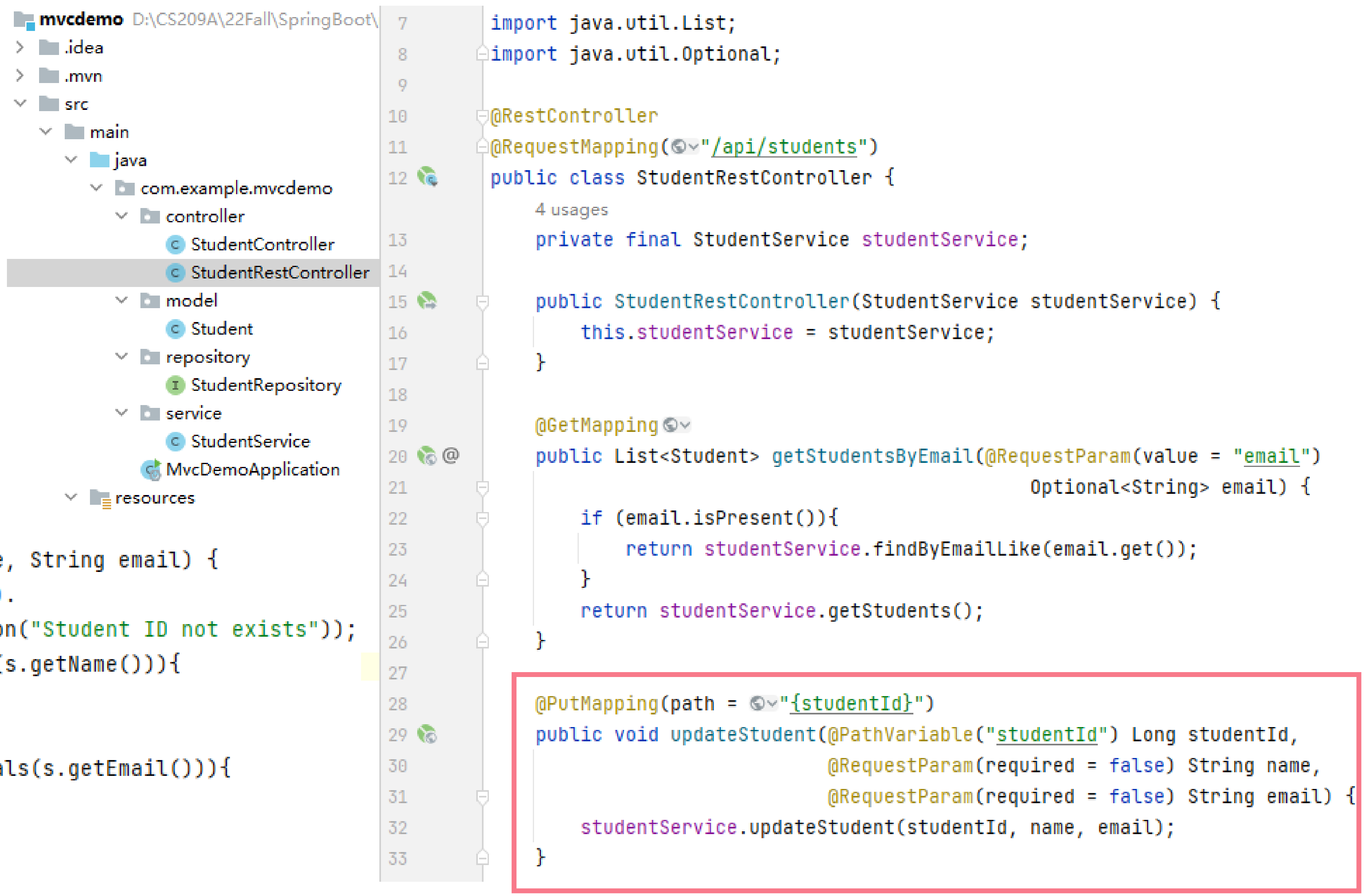
        this.studentService = studentService;
    }

    @GetMapping
    public List<Student> getStudentsByEmail(@RequestParam(value = "email")
                                             Optional<String> email) {
        if (email.isPresent()){
            return studentService.findByEmailLike(email.get());
        }
        return studentService.getStudents();
    }

    @PutMapping(path = "{studentId}")
    public void updateStudent(@PathVariable("studentId") Long studentId,
                              @RequestParam(required = false) String name,
                              @RequestParam(required = false) String email) {
        studentService.updateStudent(studentId, name, email);
    }
```

PUT http://localhost:8080/api/students/2?name=Alan&email=alan@gmail.com

## RestController



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        studentService.updateStudent(studentId, name, email);
    }
```
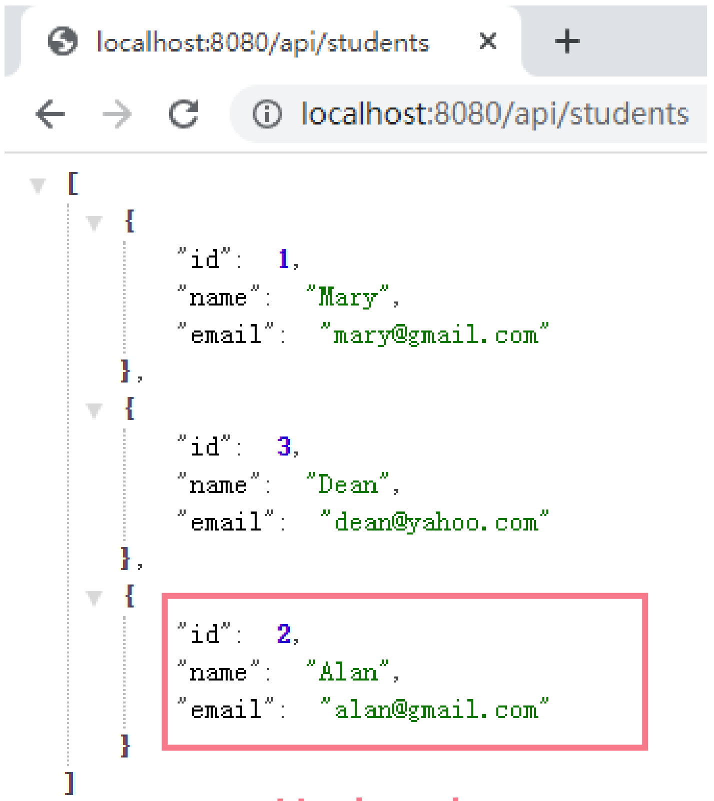

```java
@Transactional
public void updateStudent(Long studentId, String name, String email) {
    Student s = studentRepository.findById(studentId).
            orElseThrow(()-> new IllegalStateException("Student ID not exists"));
    if(name!=null && name.length()>0 && !name.equals(s.getName())){
        s.setName(name);
    }
    if(email!=null && email.length()>0 && !email.equals(s.getEmail())){
        s.setEmail(email);
    }
}
```

PUT http://localhost:8080/api/students/2?name=Alan&email=alan@gmail.com

## RestController



localhost:8080/api/students

```
[
  {
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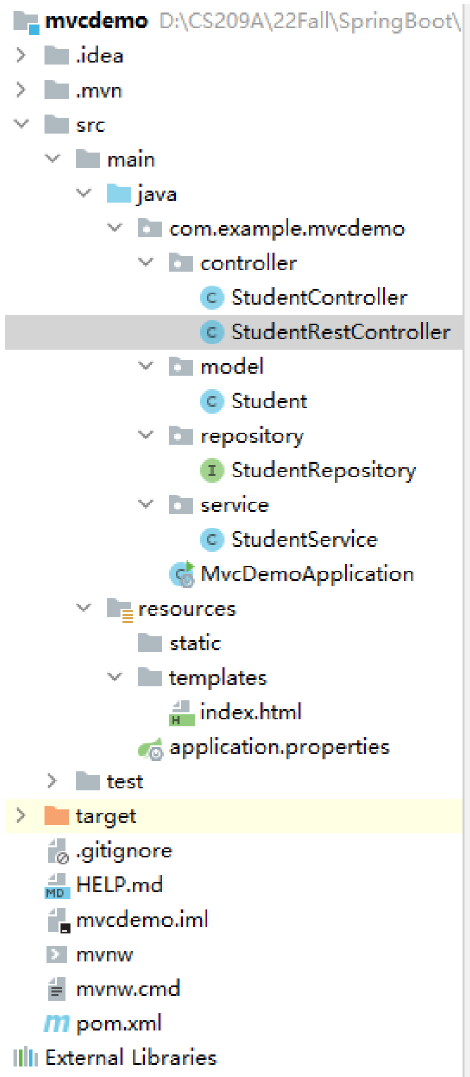
    "name": "Mary",
    "email": "mary@gmail.com"
  },
  {
    "id": 3,
    "name": "Dean",
    "email": "dean@yahoo.com"
  },
  {
    "id": 2,
    "name": "Alan",
    "email": "alan@gmail.com"
  }
]
```

Updated



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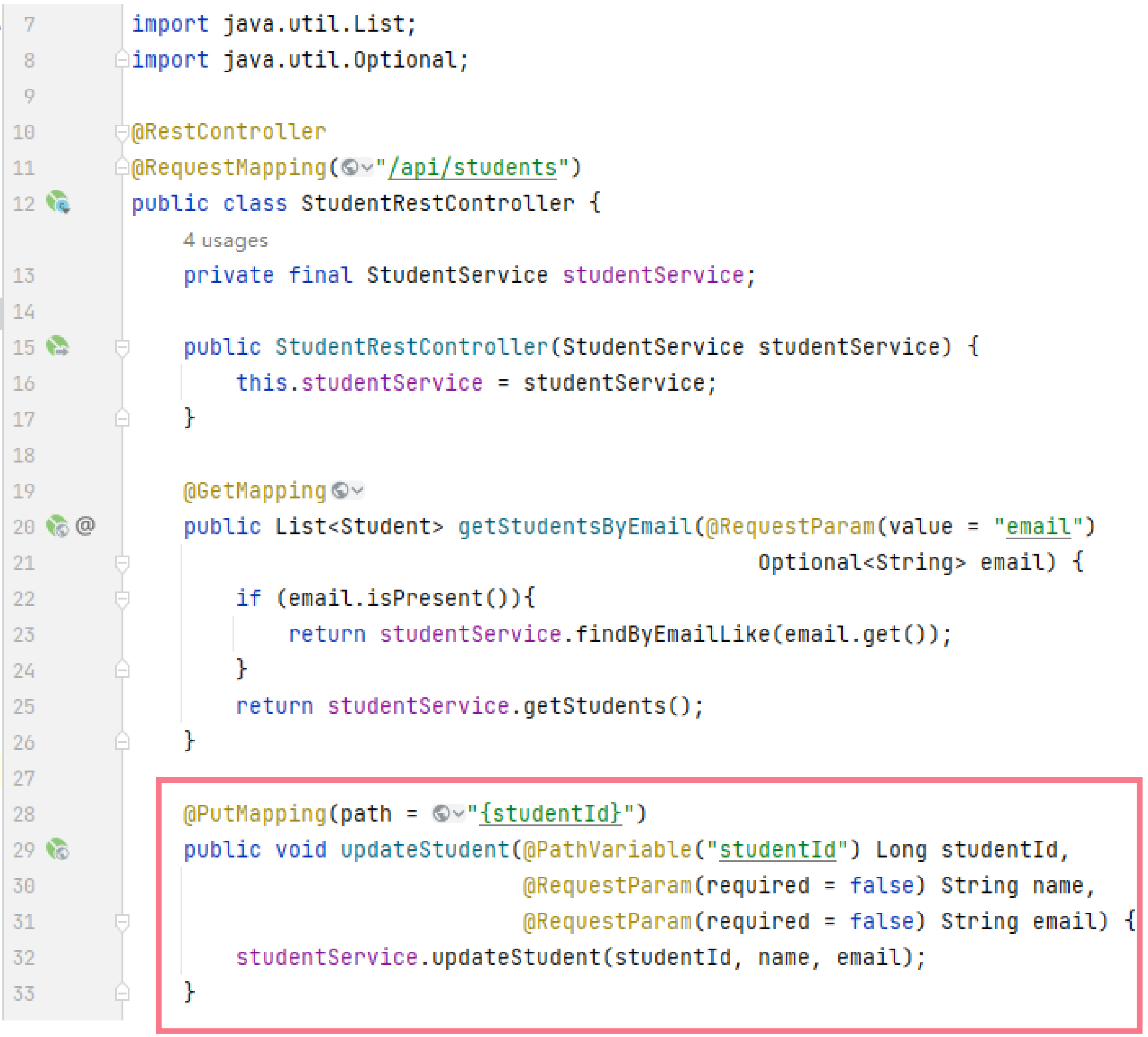

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        if (email.isPresent()){
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    @PutMapping(path = "{studentId}")
    public void updateStudent(@PathVariable("studentId") Long studentId,
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                              @RequestParam(required = false) String email) {
        studentService.updateStudent(studentId, name, email);
    }
```

## Next Lecture

- Testing
- Logging