Spring Boot Core

1. What is Spring Boot?

Definition:
Spring Boot is an **open-source, Java-based framework** built on top of the **Spring Framework** that is designed to make **application development faster and easier** by eliminating boilerplate configurations.

It follows the principle of **"Convention over Configuration"**, meaning you don't have to manually configure everything—Spring Boot provides sensible defaults.

Key Idea:

- Instead of writing hundreds of XML configuration lines (like in traditional Spring), Spring Boot automatically sets up most things using **auto-configuration**.
- You can focus on **business logic** instead of repetitive setup.

Example Analogy:
Think of **Spring Framework** as a "kitchen with all raw ingredients and utensils", and **Spring Boot** as a "kitchen where ingredients are pre-prepped, utensils are set, and you can start cooking right away".

Core Features:

- **Standalone Applications** – No need for an external server; runs with **embedded Tomcat/Jetty**.
- **Auto Configuration** – Automatically configures beans & settings based on dependencies.
- **Production Ready** – Metrics, health checks, and monitoring out of the box.
- **Minimal XML** – Most configurations are in application.properties or application.yml.
- **Dependency Management** – Uses **Spring Boot Starter** dependencies to simplify adding required libraries.

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2. Why Use Spring Boot – Advantages & Use Cases

Advantages

1. **Fast Development**
   - Rapid application development with minimal configuration.
   - Default settings and prebuilt features save time.
2. **Embedded Servers**
   - Built-in **Tomcat**, **Jetty**, or **Undertow** so no need to deploy WAR files manually.
3. **Auto Configuration**
   - Detects and configures beans automatically based on the libraries you use.
4. **Starter Dependencies**
   - One dependency (e.g., spring-boot-starter-web) pulls all required libraries.
5. **Production-Ready Features**
   - Built-in health checks, metrics, logging, and application monitoring.
6. **Microservices Friendly**
   - Ideal for **microservices architecture** with Spring Cloud integration.
7. **No XML Configuration**
   - Mostly annotation-driven (@SpringBootApplication, @RestController, etc.).
8. **Wide Community & Ecosystem**
   - Backed by Pivotal/VMware with vast community support.

Use Cases

1. **REST APIs and Web Applications**
   - Build backend APIs quickly for mobile or web applications.
2. **Microservices Architecture**
   - Spring Boot + Spring Cloud = powerful, scalable, distributed services.
3. **Enterprise Applications**
   - Large-scale systems with built-in security, transaction management, and monitoring.
4. **Event-Driven Systems**
   - With Spring Kafka, Spring AMQP, etc., for messaging-based solutions.

5. **Batch Processing**
    - Automated job scheduling and batch jobs with **Spring Batch**.
6. **Cloud-Native Applications**
    - Works seamlessly with AWS, Azure, GCP, Kubernetes, and Docker.

3. Features of Spring Boot

Spring Boot comes with a rich set of features that make Java application development **faster, easier, and more production-ready**.

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1. Auto-Configuration

- Automatically configures Spring Beans based on the libraries in the project classpath.
- Example:
    - If spring-boot-starter-web is present, it configures **Tomcat**, **Spring MVC**, and JSON converters automatically.
- Eliminates the need for manual XML or Java-based configuration.

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2. Standalone Applications

- Runs as a **standalone Java application** without needing an external application server.
- Uses **embedded servers** (Tomcat, Jetty, or Undertow).
- Run directly using:

  ```
  java -jar myapp.jar
  ```

- No WAR deployment to servers like Tomcat manually.

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3. Spring Boot Starters

- Special curated **dependency descriptors** that group commonly used dependencies for a particular functionality.
- Example:

    - spring-boot-starter-web → Spring MVC, Jackson, Tomcat, and logging libraries.
    - spring-boot-starter-data-jpa → JPA + Hibernate + Database connectors.
- Saves time by avoiding manual dependency version management.

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4. Spring Boot CLI (Command Line Interface)

- Allows you to run and test Spring Boot applications quickly using Groovy scripts.
- Ideal for prototyping without full setup.
- Example:

  spring run app.groovy

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5. Production-Ready Features (Actuator)

- The **Spring Boot Actuator** module provides:
    - Health checks (/actuator/health)
    - Application metrics (CPU, memory usage)
    - Environment properties
    - Logging levels at runtime
- Useful for monitoring and managing applications in production.

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6. No XML Configuration

- Entirely **annotation-driven**.
- Uses @SpringBootApplication, @Configuration, @EnableAutoConfiguration, and @ComponentScan instead of large XML files.
- Example:

  @SpringBootApplication
  public class MyApp { ... }

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7. Layered Architecture Support

- Follows a clean architecture:
  - **Controller Layer** – Handles HTTP requests.
  - **Service Layer** – Business logic.
  - **Repository Layer** – Data access.
  - **Model Layer** – Data structures.
- Promotes separation of concerns.

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8. Externalized Configuration

- Configuration can be stored in:
  - application.properties
  - application.yml
  - Environment variables
  - Command-line arguments
- Example (application.properties):

  server.port=9090
  spring.datasource.url=jdbc:mysql://localhost:3306/mydb

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9. DevTools for Hot Reload

- **Spring Boot DevTools** automatically restarts the application when code changes are detected.
- Speeds up development and testing.

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10. Easy Integration with Other Technologies

- Works seamlessly with:
  - Spring Security
  - Spring Data
  - Spring Cloud
  - Messaging tools (Kafka, RabbitMQ)
  - Databases (MySQL, PostgreSQL, MongoDB)

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11. Microservices Ready

- Provides everything required to build, run, and monitor **microservices**.
- Supports distributed configuration, service discovery, and API gateways via Spring Cloud.

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12. Logging Support

- Built-in logging with **Logback**.
- Can be customized via properties:

  logging.level.org.springframework=DEBUG
  logging.file.name=app.log

 In short: Spring Boot's features aim to **reduce boilerplate, speed up development, and make applications production-ready** out of the box.

4. Spring vs Spring Boot – Key Differences

Spring Boot is **built on top of Spring Framework** but adds extra features for faster development.

Aspect	Spring Framework	Spring Boot
Definition	A comprehensive framework for Java application development providing dependency injection, AOP, transaction management, etc.	An extension of Spring that simplifies setup, configuration, and deployment with auto-configuration and embedded servers.
Setup & Configuration	Requires manual setup (XML or Java-based configuration).	Auto-configuration; minimal manual setup needed.
Server Management	Requires an external server (Tomcat, Jetty, etc.) to deploy WAR files.	Comes with **embedded servers** (Tomcat, Jetty, Undertow) — runs as a standalone application.
Dependency Management	Developers must specify each dependency and its version.	Uses **Spring Boot Starters** to group and manage dependencies

Aspect	Spring Framework	Spring Boot
		automatically.
Project Structure	Requires more boilerplate code and configurations.	Opinionated defaults with ready-to-use project structure.
Deployment	Deploys on application servers like Tomcat, WebLogic, GlassFish, etc.	Deploys directly as a JAR with an embedded server using java -jar.
Learning Curve	Steeper — requires more understanding of configurations.	Easier for beginners due to convention over configuration.
Production-Ready Tools	No built-in production features; need manual integration.	Comes with **Spring Boot Actuator** for health checks, metrics, and monitoring.
Use Case	Suitable for complex, enterprise applications where fine-grained control over configuration is required.	Ideal for microservices, REST APIs, and quick application development.
Example Startup	Configure DispatcherServlet, ViewResolver, DataSource manually.	Just annotate with @SpringBootApplication and run.

Quick Analogy

- **Spring** = A fully stocked **kitchen** where you must set up everything (stove, utensils, ingredients).
- **Spring Boot** = A **ready-to-cook meal kit** — most things are prepped; you just add final touches and start cooking.

Key Takeaway:
Spring Boot is **not a replacement** for Spring — it's a **tool to make Spring development faster, easier, and production-ready**.

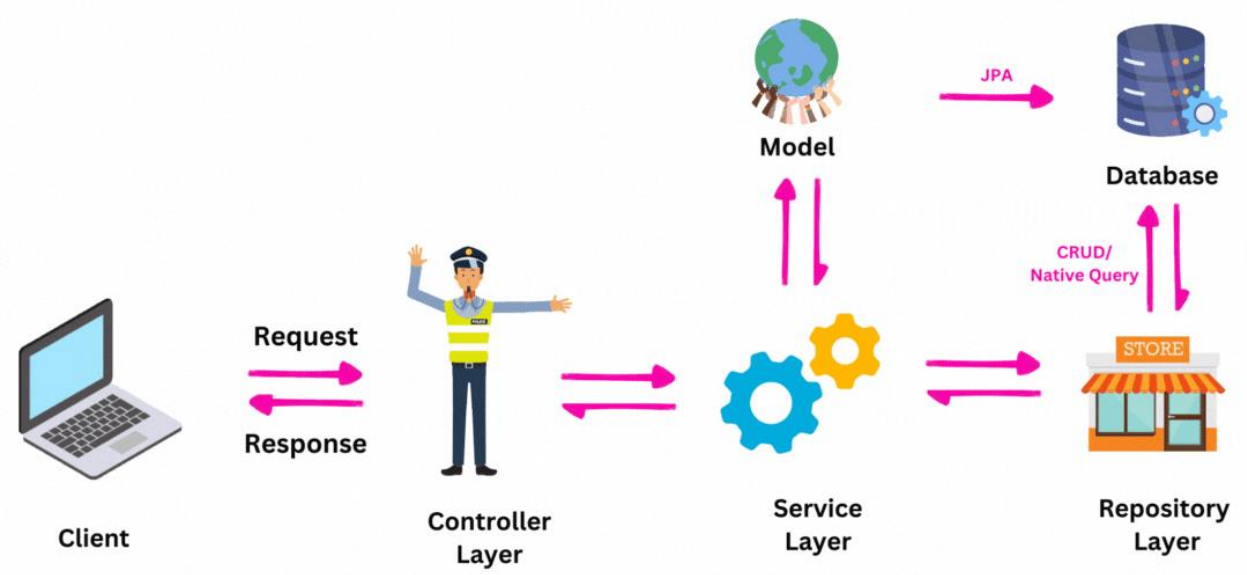
5. Spring Boot Architecture

Spring Boot's architecture builds on the **Spring Framework** but adds extra layers for **auto-configuration, embedded servers, and production-ready features**.
It follows a layered structure where each layer plays a specific role.

High-Level Overview

Main Components:

1. **Client Layer** – User or application that sends requests.
2. **Server Layer** – Embedded server that receives and processes requests.
3. **Spring Container** – Core of Spring that manages beans, dependency injection, and configurations.
4. **Auto-Configuration** – Automatically sets up beans and services based on classpath dependencies.
5. **Application Layer** – Your business logic (Controllers, Services, Repositories).



1. Client Layer

- This is where the **request originates**.
- Can be:
  - Web browser

    - Mobile app
    - API consumer (Postman, Curl, another microservice)
- Sends HTTP requests to the application (e.g., GET /users).

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2. Server Layer (Embedded Server)

- Spring Boot runs with an **embedded server** like:
    - **Tomcat** (default)
    - Jetty
    - Undertow
- This server listens for HTTP requests and forwards them to the Spring DispatcherServlet.
- No need for manual deployment to an external server.

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3. Spring Container

- Core part of **Spring Framework**.
- Responsible for:
    - Creating and managing beans.
    - Handling **Dependency Injection** (DI).
    - Managing application lifecycle.
- Uses **IoC (Inversion of Control)** to provide required dependencies automatically.

Key modules involved:

- **DispatcherServlet** – Front controller that routes requests to controllers.
- **Handler Mapping** – Finds the correct controller method for a given URL.
- **View Resolver** – Decides how to render the response (JSON, HTML, etc.).

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4. Auto-Configuration

- Spring Boot **automatically configures** the application based on:
    1. **Classpath dependencies** – e.g., if spring-boot-starter-data-jpa is present, it sets up JPA and Hibernate automatically.

2. **Property settings** in application.properties or application.yml.

- Uses the @EnableAutoConfiguration annotation (part of @SpringBootApplication).
- If you want to override defaults, you can provide **custom configuration**.

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5. How the Flow Works

1. **Client** sends a request (e.g., GET /hello).
2. **Embedded Server** (Tomcat) receives it.
3. Request is passed to **DispatcherServlet** in the **Spring Container**.
4. **Handler Mapping** finds the right Controller method.
5. Controller calls **Service Layer** for business logic.
6. Service calls **Repository Layer** to interact with the database.
7. Response goes back the same route to the **Client**.

Key Benefits of this Architecture

- **Loose Coupling** – Components are independent.
- **Scalability** – Suitable for microservices.
- **Flexibility** – Easy to replace beans or configs.
- **Minimal Configuration** – Thanks to auto-configuration.

 In short:
Spring Boot architecture combines **Spring's IoC container** with **auto-configuration** and **embedded servers**, making it possible to build and run production-ready applications with minimal setup.

6. Creating Spring Boot Applications

Spring Boot applications can be created **quickly and easily** using two main approaches:

1. **Using Spring Initializr Website**
2. **Using IDE Tools (IntelliJ IDEA, Spring Tool Suite, Eclipse)**

1.Using Spring Initializr (Website)

Spring Initializr is an online project generator that helps you create a ready-to-use Spring Boot project structure in a few clicks.

Steps:

1. **Open Website**
   Visit https://start.spring.io
2. **Choose Project Type**
   - **Maven Project** (most common) or **Gradle Project**
3. **Select Language**
   - Java (default), Kotlin, or Groovy
4. **Spring Boot Version**
   - Choose the latest **stable** release.
5. **Project Metadata**
   - **Group**: Reverse domain name (e.g., com.example)
   - **Artifact**: Project name (e.g., demo)
   - **Name**: Application name
   - **Package Name**: Defaults to group + artifact
6. **Packaging & Java Version**
   - Packaging: **Jar** (default) or War
   - Java: Select your installed Java version (e.g., 17)
7. **Add Dependencies**
   - Click **Add Dependencies** and choose relevant starters.
     Example for REST API:
     - Spring Web
     - Spring Boot DevTools (for hot reload)
     - Spring Data JPA
     - MySQL Driver

8. **Generate Project**
    - Click **Generate** to download a .zip file.
    - Extract it and open in your IDE.

Advantages of using Spring Initializr:

- No manual folder structure creation.
- Automatically adds correct dependencies and versions.
- Works with Maven and Gradle.

2.Using an IDE (IntelliJ IDEA, STS, Eclipse)

Most modern Java IDEs have **Spring Initializr integration** built in.

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a) IntelliJ IDEA (Ultimate / Community with Plugin)

1. **File → New → Project**
2. Select **Spring Initializr**.
3. Choose SDK (Java version).
4. Fill **Project Metadata** (Group, Artifact, etc.).
5. Select **Dependencies** from built-in list.
6. Finish → IntelliJ downloads and sets up the project.

7. Internal Flow of a Spring Boot Application

Spring Boot's internal working is based on **Spring Framework's core concepts** (IoC, DI, DispatcherServlet) but adds **auto-configuration, embedded server, and starters** to simplify the process.

Step-by-Step Flow

1 Application Startup

- The application starts with a **main class** annotated with:

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

- @SpringBootApplication is a **meta-annotation** that combines:
  - @Configuration – Marks class as a source of bean definitions.
  - @EnableAutoConfiguration – Enables Spring Boot's auto-config.
  - @ComponentScan – Scans for components in the package.
- **SpringApplication.run()** triggers:

1. **Bootstrapping** – Creates an ApplicationContext (Spring Container).
2. **Loads Beans** – Scans and registers beans in IoC container.
3. **Applies Auto-Configuration** based on dependencies.

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2 Auto-Configuration Phase

- Enabled by @EnableAutoConfiguration.
- Uses spring.factories files from dependencies (inside JARs) to check which auto-configurations to apply.
- Example:
  - If spring-boot-starter-web is present → Configures DispatcherServlet, Tomcat, JSON converters automatically.
  - If spring-boot-starter-data-jpa is present → Configures Hibernate, DataSource, JPA repositories.

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3 Embedded Server Initialization

- Based on dependencies, Spring Boot starts:

  - **Tomcat** (default)
  - Jetty / Undertow (if added)
- Runs within the same JVM, so the app can be started with:

  bash
  CopyEdit
  java -jar myapp.jar

- No WAR deployment needed.

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4 Request Handling (Spring MVC Flow)

When a client sends an HTTP request:

1. **Embedded Server** receives the request.
2. **DispatcherServlet** (Front Controller) processes it.
3. **Handler Mapping** finds the appropriate controller method based on URL and HTTP method.
4. The **Controller** executes and calls:
   - **Service Layer** for business logic.
   - **Repository Layer** for database interaction (if needed).
5. The response is returned as:
   - JSON/XML (via @RestController or @ResponseBody)
   - HTML page (via templates like Thymeleaf)

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5 Response Generation

- **View Resolver** decides how to render the response:
  - JSON for APIs
  - HTML for web pages
- Response is sent back to the **Client** through the embedded server.

```
Application Start
   |
   v
@SpringBootApplication --> SpringApplication.run()
   |
   v
Spring Container (ApplicationContext) Created
   |
   v
Auto-Configuration Applied
   |
   v
Embedded Server Started (Tomcat/Jetty)
   |
   v
Wait for Requests
   |
   v
[Request Arrives] --> DispatcherServlet
   |                        |
   |--- Handler Mapping --|
   |                        |
   |--> Controller --> Service --> Repository --> Database
   |
[Response Sent Back]
```

 In short:
Spring Boot starts by **bootstrapping the Spring container**, applies **auto-configuration** based on dependencies, starts an **embedded server**, and uses the **Spring MVC flow** to handle requests and return responses.

8. @SpringBootApplication Annotation

The @SpringBootApplication annotation is the **main entry point** for a Spring Boot application.
It is placed on the **main class** of your application to enable **auto-configuration, component scanning, and bean registration**.

Definition

@SpringBootApplication is a **meta-annotation** that combines three commonly used Spring annotations:

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

```
}
```

It Equals To:

```
@Configuration
@EnableAutoConfiguration
@ComponentScan
public class MyApp {
   ...
}
```

1.@Configuration

- Marks the class as a **configuration class** for Spring's IoC container.
- Allows you to define **beans** using @Bean methods.
- Example:

```
@Configuration
public class MyConfig {
   @Bean
   public MyService myService() {
      return new MyService();
   }
}
```

---

2. @EnableAutoConfiguration

- Tells Spring Boot to **automatically configure** the application based on dependencies present in the classpath.
- Uses the spring.factories mechanism to load configurations.
- Example:
    - If spring-boot-starter-web is present → Configures DispatcherServlet, Jackson, Tomcat automatically.
- You can **exclude** specific auto-configurations:

```
@SpringBootApplication(exclude = { DataSourceAutoConfiguration.class
})
```

3.@ComponentScan

- Scans the **current package and sub-packages** for:
  - @Component
  - @Service
  - @Repository
  - @Controller
  - @RestController
- Registers them as Spring Beans in the IoC container.
- Example:

  @Component
  public class MyBean { ... }

  This bean will be discovered automatically.

Flow When Using @SpringBootApplication

1. Marks the class as a configuration class (@Configuration).
2. Triggers auto-configuration (@EnableAutoConfiguration).
3. Scans and registers all beans in the package (@ComponentScan).
4. Boots the application using SpringApplication.run()

```
@SpringBootApplication
        |
        +--> @Configuration → Bean definitions
        |
        +--> @EnableAutoConfiguration → Auto-setup based on dependencies
        |
        +--> @ComponentScan → Scan beans in package
```

 Key Takeaway:
@SpringBootApplication **reduces boilerplate** by combining three essential Spring annotations into one, making it the standard way to start a Spring Boot application.

9. Spring Boot Auto-Configuration

Spring Boot **Auto-Configuration** is one of its **core features** that allows it to automatically configure your application **based on the dependencies available in the classpath** — without requiring manual configuration.

What is Auto-Configuration?

- Instead of manually defining beans, data sources, and configurations, Spring Boot **intelligently guesses and sets them up**.
- It uses sensible **defaults** but lets you **override** them if needed.

Annotation: @EnableAutoConfiguration

- The main trigger for auto-configuration in Spring Boot.
- **Included inside** @SpringBootApplication.
- Instructs Spring Boot to **scan the classpath** and **load configuration classes** from META-INF/spring.factories.

How Auto-Configuration Works (Step-by-Step)

1. **Classpath Scanning**
    - Spring Boot looks at the **dependencies** in your pom.xml or build.gradle.
    - Example:
        - If spring-boot-starter-web is present → Configures Spring MVC, Jackson, and an embedded Tomcat server.
        - If spring-boot-starter-data-jpa is present → Configures Hibernate, JPA repositories, and a DataSource.
2. **Find Auto-Configuration Classes**
    - Spring Boot loads a list of auto-configuration classes from:

      META-INF/spring.factories

    - Each dependency may contribute its own auto-configuration classes.

3. **Conditional Configuration**
    - Each auto-configuration class is annotated with **conditional annotations**:
        - @ConditionalOnClass – Apply config only if a specific class is on the classpath.
        - @ConditionalOnMissingBean – Apply config only if a bean is not already defined by the user.
        - @ConditionalOnProperty – Apply config based on properties in application.properties.
4. **Bean Creation**
    - Auto-configuration creates beans for components like:
        - DataSource
        - EntityManagerFactory
        - MessageConverters
        - ViewResolvers
5. **User Overrides**
    - If you define a bean manually, **auto-config will back off**.
    - Example:

      ```
      @Bean
      public DataSource myCustomDataSource() {
         return new HikariDataSource();
      }
      ```

      → Spring Boot won't create its default DataSource.

Example

If your project contains:

```
<dependency>
   <groupId>org.springframework.boot</groupId>
   <artifactId>spring-boot-starter-web</artifactId>
</dependency>
```

Spring Boot will:

- Detect DispatcherServlet and Tomcat on the classpath.
- Automatically configure:

- Web server (Tomcat)
- JSON support (Jackson)
- Static resource handling
- Error page handling

Disabling Auto-Configuration

You can disable specific configurations:

```
@SpringBootApplication(exclude = { DataSourceAutoConfiguration.class })
public class MyApp { ... }
```

Key Conditional Annotations in Auto-Configuration

Annotation	Purpose
@ConditionalOnClass	Config only if a class is on the classpath
@ConditionalOnMissingBean	Config only if a bean is not already present
@ConditionalOnProperty	Config only if a property is set in application.properties
@ConditionalOnMissingClass	Config only if a class is **not** on the classpath

10. Difference between Autowiring and Auto-Configuration in Spring Boot

1. Autowiring

- **Definition:**
  Autowiring is the **process of automatically injecting bean dependencies** into other beans by Spring's IoC (Inversion of Control) container.
- **Purpose:**
  To avoid manual bean wiring using XML or explicit @Bean methods.
- **How it Works:**
  - Spring looks for a **matching bean** in the application context.
  - Injects it into the target class **based on type, name, or constructor**.
  - Controlled mainly via the @Autowired annotation.

- **Scope:**
  Works **within the existing beans** in the Spring Application Context.
  It **does not create beans**; it only injects already defined ones.
- **Example:**

```
@Service
public class UserService {
   @Autowired
   private UserRepository userRepository;
}
```

Here, Spring **finds** UserRepository bean and injects it into UserService.

---

2. Auto-Configuration

- **Definition:**
  Auto-Configuration is the **process where Spring Boot automatically creates and configures beans** for you based on the classpath contents and properties.
- **Purpose:**
  To reduce manual configuration by providing sensible defaults for many common scenarios.
- **How it Works:**
  - Triggered by the @EnableAutoConfiguration (inside @SpringBootApplication).
  - Uses META-INF/spring.factories to load configuration classes.
  - Checks for **specific classes on the classpath** and creates beans accordingly.
- **Scope:**
  It **creates and registers beans** automatically **before** autowiring happens.
- **Example:**
  If you add **Spring Web** dependency:
  - Auto-Configuration will create DispatcherServlet, DefaultErrorController, etc., without you writing a single bean definition.

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3. Key Differences Table

Aspect	Autowiring	Auto-Configuration
Definition	Injects existing beans into other beans	Automatically creates and configures beans
Purpose	Dependency injection	Reduce boilerplate configuration
Trigger	@Autowired, @Inject	@EnableAutoConfiguration
Bean Creation?	No – only injects	Yes – creates beans if needed
When it Happens	After beans are created	Before autowiring
Customization	Choose which bean to inject	Override defaults with properties or custom beans

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In short:

- **Auto-Configuration**: Decides *what beans to create* based on your project setup.
- **Autowiring**: Decides *where to inject* those beans inside your code.

11. Spring Boot Starters & Dependencies

1. What are Starters in Spring Boot?

- **Definition:**
  Starters are **pre-defined dependency descriptors** provided by Spring Boot to simplify dependency management.
  Instead of adding multiple dependencies manually in your pom.xml (Maven) or build.gradle (Gradle), you just include **one starter**, and it will pull all the required libraries for that module.
- **Why Starters?**
  - Avoids **dependency hell** (version mismatches).
  - Reduces boilerplate setup.
  - Brings **opinionated defaults** so you don't have to manually configure libraries.

---

2. Naming Convention

- All Spring Boot starters follow the pattern:
- spring-boot-starter-<module>
- Examples:
    - spring-boot-starter-web → for building web applications.
    - spring-boot-starter-data-jpa → for JPA and Hibernate integration.
    - spring-boot-starter-security → for Spring Security.

---

3. Commonly Used Spring Boot Starters

Starter Name	Purpose
spring-boot-starter	Core starter including logging, YAML/JSON parsing, etc.
spring-boot-starter-web	For building web apps & REST APIs using Spring MVC + Tomcat (default) or Jetty/Undertow.
spring-boot-starter-data-jpa	For database interaction using JPA (Hibernate).
spring-boot-starter-thymeleaf	For server-side HTML rendering with Thymeleaf template engine.
spring-boot-starter-security	Adds Spring Security for authentication & authorization.
spring-boot-starter-test	Brings JUnit, Mockito, Spring Test for unit & integration testing.
spring-boot-starter-mail	For sending emails using JavaMail.
spring-boot-starter-actuator	For monitoring & management endpoints (health, metrics, etc.).
spring-boot-starter-batch	For batch processing jobs.
spring-boot-starter-validation	Adds Hibernate Validator for bean validation.

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4. Example – Adding Starter in Maven

<dependencies>

```
    <!-- For REST APIs -->
    <dependency>
        <groupId>org.springframework.boot</groupId>
        <artifactId>spring-boot-starter-web</artifactId>
    </dependency>

    <!-- For Database -->
    <dependency>
        <groupId>org.springframework.boot</groupId>
        <artifactId>spring-boot-starter-data-jpa</artifactId>
    </dependency>

    <!-- For Testing -->
    <dependency>
        <groupId>org.springframework.boot</groupId>
        <artifactId>spring-boot-starter-test</artifactId>
        <scope>test</scope>
    </dependency>
</dependencies>
```

---

5. How Starters Work Internally

- Starters are **just dependency groups** declared in their own pom.xml.
- They **don't contain actual code** but **reference the real libraries**.
- Spring Boot uses **Spring Boot Dependency Management** to ensure **version compatibility** between these libraries.

Example:
spring-boot-starter-web includes:

- spring-web
- spring-webmvc
- jackson-databind (for JSON)
- spring-boot-starter-tomcat
- spring-boot-starter-validation

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6. Benefits of Spring Boot Starters

- Easy dependency management
- No need to manually search for compatible versions
- Follows opinionated defaults for faster development
- Reduces boilerplate pom.xml clutter

12. Stereotype Annotations in Spring Boot

Stereotype annotations are **special annotations** provided by Spring Framework to **mark classes as specific Spring-managed components** in the application context. They help **Spring automatically detect and register beans** during component scanning.

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1. @Component

- **Definition:** Generic stereotype annotation that marks a class as a Spring-managed bean.
- **Purpose:** Used for any **generic component** that doesn't fit into a specific role (service, repository, etc.).
- **Where to use:** Utility classes, helper classes, or any bean you want Spring to manage.
- **Example:**

```
import org.springframework.stereotype.Component;

@Component
public class EmailValidator {
   public boolean isValid(String email) {
      return email.contains("@");
   }
}
```

Here, EmailValidator will be detected and registered as a **bean** automatically.

---

2. @Service

- **Definition:** Specialized version of @Component used for **service layer classes**.
- **Purpose:** Indicates that the class contains **business logic**.
- **Where to use:** Classes that perform calculations, processing, or coordinate business rules.
- **Example:**

```
import org.springframework.stereotype.Service;

@Service
public class PaymentService {
   public void processPayment(double amount) {
      System.out.println("Processing payment of " + amount);
   }
}
```

 Internally, @Service works like @Component but is used for **semantic clarity**.

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3. @Repository

- **Definition:** Specialized @Component for **data access layer** (DAO classes).
- **Purpose:**
  - Marks classes that interact with the **database**.
  - Adds **exception translation**: converts database exceptions into **Spring's DataAccessException**.
- **Where to use:** JDBC, JPA, Hibernate repository classes.
- **Example:**

```
import org.springframework.stereotype.Repository;

@Repository
public class UserRepository {
   public String findUserById(int id) {
      return "User with ID: " + id;
   }
```

```
}
```

---

4. @Controller

- **Definition:** Specialized @Component for **MVC web controllers**.
- **Purpose:** Handles **web requests** and returns **views (HTML pages)**.
- **Where to use:** Spring MVC applications (not REST APIs).
- **Example:**

```
import org.springframework.stereotype.Controller;
import org.springframework.web.bind.annotation.GetMapping;

@Controller
public class HomeController {
   @GetMapping("/")
   public String homePage() {
      return "index"; // returns view name
   }
}
```

Here, "index" refers to a **template file** like index.html.

---

5. @RestController

- **Definition:** Combination of @Controller + @ResponseBody.
- **Purpose:** Used for **REST APIs**.
  Automatically serializes Java objects to **JSON/XML** in the response.
- **Where to use:** REST API endpoints.
- **Example:**

```
import org.springframework.web.bind.annotation.GetMapping;
import org.springframework.web.bind.annotation.RestController;

@RestController
public class ProductController {
   @GetMapping("/products")
```

```
    public String getProducts() {
        return "List of products";
    }
}
```

 Here, "List of products" will be sent **as raw text/JSON**, not as a view name.

Summary Table

Annotation	Layer / Purpose	Special Feature
@Component	Generic bean	Basic Spring bean
@Service	Service layer	Business logic clarity
@Repository	DAO layer	Exception translation
@Controller	MVC controller	Returns view name
@RestController	REST API	JSON/XML response

 Key Points to Remember

- All these annotations are **detected via Component Scanning** (enabled by @ComponentScan).
- They make the code **more readable** by clearly indicating the role of each class.
- @RestController is for **APIs**, while @Controller is for **web pages**.

13. Dependency Injection in Spring Boot

1. What is Dependency Injection (DI)?

- **Definition:** A design pattern where the dependencies (objects a class needs) are provided externally rather than the class creating them itself.
- **Purpose in Spring Boot:**
    - Promotes loose coupling between classes.
    - Makes code easier to test, maintain, and extend.
- Spring's IoC (Inversion of Control) container manages DI by creating and injecting beans automatically.

Types of Dependency Injection in Spring Boot

Spring Boot supports **three main types**:

---

1. Constructor Injection (Recommended)

Definition: Dependencies are passed via the class constructor.

Example:

```
import org.springframework.stereotype.Component;

@Component
public class Car {
   private final Engine engine;

   // Constructor Injection
   public Car(Engine engine) {
      this.engine = engine;
   }

   public void start() {
      engine.run();
   }
}
```

Why Constructor Injection is Recommended:

- Makes dependencies **immutable** (use final keyword).
- Ensures dependency is not null at runtime.
- Works well with testing frameworks.
- Detects missing dependencies at compile-time.

2.Setter Injection

Definition: Dependencies are passed through setter methods after the object is created.

Example:

```
import org.springframework.stereotype.Component;

@Component
public class Car {
   private Engine engine;

   // Setter Injection
   public void setEngine(Engine engine) {
      this.engine = engine;
   }

   public void start() {
      engine.run();
   }
}
```

When to Use:

- For **optional** dependencies.
- When dependencies can change during the object's lifecycle.

---

3. Field Injection (Not Recommended for Production)

Definition: Dependencies are injected directly into the class fields using @Autowired.

Example:

```
import org.springframework.beans.factory.annotation.Autowired;
import org.springframework.stereotype.Component;

@Component
```

```
public class Car {

   @Autowired
   private Engine engine;  // Field Injection

   public void start() {
      engine.run();
   }
}
```

Drawbacks:

- Makes testing harder (requires reflection to set private fields in tests).
- Hides dependencies (less clear what the class actually needs).
- Breaks immutability.

Best Practices

- **Use Constructor Injection** for **mandatory** dependencies.
- **Use Setter Injection** for **optional** dependencies.
- **Avoid Field Injection** in real-world applications — keep it only for quick prototypes or very small apps.

14. Configuration Files in Spring Boot

Spring Boot provides two main ways to configure your application:

1. **application.properties** – Key-value based configuration
2. **application.yml** – YAML (hierarchical) configuration

These files allow you to define:

- Server settings
- Database connection details
- Logging levels
- Custom application properties
- Third-party library configurations

By default, **Spring Boot automatically loads these files** from:

/src/main/resources/

---

1. application.properties

- Format: **key=value**
- Simple and widely used.
- Good for small configurations.

Example:

```
# Server configuration
server.port=8081
server.servlet.context-path=/myapp

# Database configuration
spring.datasource.url=jdbc:mysql://localhost:3306/mydb
spring.datasource.username=root
spring.datasource.password=admin
spring.jpa.hibernate.ddl-auto=update

# Logging configuration
logging.level.org.springframework=DEBUG
```

---

2. application.yml

- Format: **YAML** (Yet Another Markup Language)
- Supports hierarchical/nested data.
- More readable for complex configurations.

Example:

```
server:
  port: 8081
  servlet:
    context-path: /myapp

spring:
  datasource:
    url: jdbc:mysql://localhost:3306/mydb
    username: root
```

```
    password: admin
  jpa:
    hibernate:
      ddl-auto: update

logging:
  level:
    org.springframework: DEBUG
```

---

application.properties vs application.yml

Feature	application.properties	application.yml
Format	Key-Value	Hierarchical
Readability	Less for large configs	More readable
Comments	#	#
Complex data	Harder to represent	Easy with nesting

Priority Order in Spring Boot

When both files exist:

1. application.properties
2. application.yml

The **last loaded** file overrides the previous values if keys are the same.

Profiles in Configuration Files

Spring Boot supports **profiles** to manage different environments (dev, test, prod).

Example:

```
# application-dev.properties
server.port=8082

# application-prod.properties
```

server.port=8080

Run the application with:

java -jar myapp.jar --spring.profiles.active=dev

Best Practices

- Use **application.yml** for complex configurations.
- Keep **secrets** (passwords, keys) in environment variables or external config.
- Use **profiles** to separate environment-specific settings.
- Avoid hardcoding values in code – always externalize in config files.

15. Profiles in Spring Boot

Profiles in Spring Boot allow you to define **different configurations** for **different environments** (e.g., development, testing, production) and activate them based on the environment where the application is running.

---

1. Why Use Profiles?

- Applications behave differently in different environments.
- Example:
  - In **development**, you may use an in-memory H2 database.
  - In **production**, you may connect to MySQL/PostgreSQL.
- Profiles help **avoid hardcoding environment-specific values**.

---

2. How Profiles Work

- You create **multiple configuration files** or beans.
- You **tag them with a profile name** using @Profile.
- At runtime, you **activate a profile** via application.properties, application.yml, or command line arguments.

---

3. Activating Profiles

a) In application.properties

spring.profiles.active=dev

b) In application.yml

```
spring:
  profiles:
    active: dev
```

c) Using Command Line

java -jar myapp.jar --spring.profiles.active=prod

d) Using Environment Variables

export SPRING_PROFILES_ACTIVE=prod

---

4. Profile-Specific Properties Files

You can create separate property files for each profile:

```
application.properties         # Common properties
application-dev.properties     # Dev-specific
application-test.properties    # Test-specific
application-prod.properties    # Prod-specific
```

When a profile is active, Spring Boot **automatically loads**:

- Common properties from application.properties
- Environment-specific properties from application-{profile}.properties

---

5. Using @Profile Annotation

The @Profile annotation is used to **define beans** that should only load in a specific profile.

Example:

```
@Component
```

```
@Profile("dev")
public class DevDataSourceConfig {
   public DevDataSourceConfig() {
      System.out.println("Dev DataSource loaded");
   }
}

@Component
@Profile("prod")
public class ProdDataSourceConfig {
   public ProdDataSourceConfig() {
      System.out.println("Prod DataSource loaded");
   }
}
```

If the profile is dev, only DevDataSourceConfig will be loaded.

---

6. Multiple Profiles

You can activate **more than one profile**:

```
spring.profiles.active=dev,security
```

Or in YAML:

```
spring:
  profiles:
    active:
      - dev
      - security
```

---

7. Default Profile

- If no profile is set, **Spring Boot uses the default profile**.
- You can explicitly define:

```
spring.profiles.default=dev
```

---

8. Real-Life Example

application-dev.properties

```
spring.datasource.url=jdbc:h2:mem:devdb
spring.datasource.username=devuser
```

application-prod.properties

```
spring.datasource.url=jdbc:mysql://localhost:3306/proddb
spring.datasource.username=produser
```

Main Class

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

If we run:

java -jar app.jar --spring.profiles.active=prod

➡ The **MySQL** datasource will be used instead of H2.

---

9. Best Practices

- Keep **common configs** in application.properties.
- Use profiles for **environment-specific** settings only.
- Avoid **hardcoding environment variables** in code.
- Combine profiles when needed (e.g., dev + security).

16. Externalized Configuration & Property Injection (@Value, @ConfigurationProperties)

1. What is Externalized Configuration in Spring Boot?

Spring Boot allows you to **keep configuration values outside the source code** so that you can easily change them without modifying or recompiling your application.

- Useful for:
  - Changing database URLs
  - Switching environments (dev, test, prod)
  - Managing secrets (API keys, passwords)
- Supported file formats:
  - application.properties
  - application.yml
  - Environment variables
  - Command-line arguments
  - External config files
  - Config server (Spring Cloud)

---

2. Property Injection

Spring Boot provides **two main ways** to inject configuration values into your application:

A. Using @Value Annotation

- Injects a single property value directly from configuration files, environment variables, or system properties.

Syntax:

```
@Value("${property.key:defaultValue}")
private String value;
```

- ${property.key} → Reads the value of property.key
- :defaultValue → Optional default if property not found

Example:
application.properties

```
app.name=My Spring Boot App
app.version=1.0.0
```

Java Code

```
import org.springframework.beans.factory.annotation.Value;
import org.springframework.stereotype.Component;

@Component
public class AppConfig {

    @Value("${app.name}")
    private String appName;

    @Value("${app.version}")
    private String appVersion;

    @Value("${app.author:Unknown}") // Default value
    private String author;

    public void printConfig() {
        System.out.println("App Name: " + appName);
        System.out.println("Version: " + appVersion);
        System.out.println("Author: " + author);
    }
}
```

B. Using @ConfigurationProperties

- Binds **multiple related properties** into a Java POJO.
- Requires a prefix in properties file.
- **Better for structured data**.

Step 1 – Add Dependency
Spring Boot already includes spring-boot-configuration-processor for metadata hints (optional but recommended):

```
<dependency>
    <groupId>org.springframework.boot</groupId>
    <artifactId>spring-boot-configuration-processor</artifactId>
    <optional>true</optional>
</dependency>
```

Step 2 – Properties File

```
app.name=My Spring Boot App
app.version=1.0.0
app.author=Prathamesh Jadhav
app.features.auth=true
app.features.payment=false
```

Step 3 – Java Class

```
import org.springframework.boot.context.properties.ConfigurationProperties;
import org.springframework.stereotype.Component;

import java.util.Map;

@Component
@ConfigurationProperties(prefix = "app")
public class AppProperties {
   private String name;
   private String version;
   private String author;
   private Map<String, Boolean> features; // For nested values

   // Getters & Setters
   public String getName() { return name; }
   public void setName(String name) { this.name = name; }

   public String getVersion() { return version; }
   public void setVersion(String version) { this.version = version; }

   public String getAuthor() { return author; }
   public void setAuthor(String author) { this.author = author; }

   public Map<String, Boolean> getFeatures() { return features; }
   public void setFeatures(Map<String, Boolean> features) { this.features =
features; }
}
```

Step 4 – Using It

```
import org.springframework.beans.factory.annotation.Autowired;
import org.springframework.stereotype.Service;

@Service
public class ConfigService {
   @Autowired
   private AppProperties appProperties;

   public void displayConfig() {
      System.out.println("App Name: " + appProperties.getName());
      System.out.println("Version: " + appProperties.getVersion());
      System.out.println("Author: " + appProperties.getAuthor());
      System.out.println("Features: " + appProperties.getFeatures());
   }
}
```

---

3. Externalizing Config in Multiple Ways

Spring Boot looks for configuration in **this order (highest to lowest priority)**:

1. Command-line arguments
2. Java System properties (-Dproperty=value)
3. OS environment variables
4. Application properties inside application.properties or application.yml
5. Default values in code (@Value("${prop:default}"))

---

4. application.properties vs application.yml

Both serve the same purpose, but YAML is more structured and readable.

Example – application.yml

```
app:

name: My Spring Boot App
  version: 1.0.0
  author: Prathamesh Jadhav
  features:
```

auth: true
payment: false

17. Logging in Spring Boot (Default logging, SLF4J, Logback)

1. What is Logging in Spring Boot?

Logging is the process of recording runtime information of an application for:

- **Debugging** errors
- **Monitoring** system behavior
- **Auditing** actions
- **Performance analysis**

Spring Boot provides **default logging support** and allows integration with popular logging frameworks like:

- **Java Util Logging (JUL)**
- **Log4j 2**
- **Logback** (default)

---

2. Default Logging in Spring Boot

- **By default** Spring Boot uses **Logback** for logging.
- The logging facade used is **SLF4J** (Simple Logging Facade for Java).
- The default log pattern prints:
    - Date & time
    - Log level (INFO, DEBUG, ERROR, etc.)
    - Thread name
    - Logger name
    - Message

Example Default Log Output:

2025-08-14T10:15:30.123 INFO 12345 --- [main] com.example.demo.DemoApplication : Started DemoApplication in 3.456 seconds

Log Levels in Spring Boot:

1. **TRACE** – Detailed low-level logs for debugging.
2. **DEBUG** – Debugging information.
3. **INFO** – General application flow.
4. **WARN** – Warnings about potential problems.
5. **ERROR** – Serious issues that need attention.
6. **OFF** – Disable logging.

---

3. Changing Log Level

You can change log levels in **application.properties** or **application.yml**.

Example – application.properties

```
logging.level.root=INFO
logging.level.com.example=DEBUG
```

Example – application.yml

```
logging:
  level:
    root: INFO
    com.example: DEBUG
```

---

4. SLF4J (Logging Facade)

- **SLF4J** is a **facade** — it provides a common logging API but doesn't log by itself.
- Works with multiple logging frameworks (Logback, Log4j, etc.).
- You log using Logger from SLF4J, but the actual logging is done by the underlying framework.

Example:

```
import org.slf4j.Logger;
import org.slf4j.LoggerFactory;
import org.springframework.stereotype.Component;
```

```
@Component
public class MyService {
   private static final Logger logger = LoggerFactory.getLogger(MyService.class);

   public void processData() {
      logger.info("Processing started...");
      logger.debug("Debugging details here");
      logger.error("An error occurred");
   }
}
```

---

5. Logback (Default Implementation)

- **Logback** is the **default logging implementation** in Spring Boot.
- Supports:
    - Rolling logs (daily or size-based rotation)
    - Different formats for different environments
    - XML-based configuration

Custom Logback Configuration:
Create src/main/resources/logback-spring.xml:

```
<configuration>
   <appender name="CONSOLE" class="ch.qos.logback.core.ConsoleAppender">
      <encoder>
         <pattern>%d{yyyy-MM-dd HH:mm:ss} %-5level %logger{36} -
%msg%n</pattern>
      </encoder>
   </appender>

   <root level="INFO">
      <appender-ref ref="CONSOLE" />
   </root>
</configuration>
```

---

6. File Logging in Spring Boot

To write logs to a file, just set in application.properties:

```
logging.file.name=app.log
logging.file.path=logs
```

This will create a logs/app.log file.

---

7. Logging in Different Environments

You can set different log levels for different profiles:

```
# application-dev.properties
logging.level.root=DEBUG

# application-prod.properties
logging.level.root=ERROR
```