- **Spring IoC Container** (or **Application Context**)
  - It is the **Bean Factory**.
  - All the center or everything is the ApplicationContext -- Spring's IoC.
  - Spring IoC Container (Inversion of Control Container) is the core part of the Spring Framework responsible for:
    - creating objects (beans)
    - managing their life cycle
    - injecting dependencies
    - configuring them using annotations/XML/Java config
  - The container controls your objects → NOT you.
  - In simple terms --- **The Spring IoC Container is the engine that creates and manages all Spring beans and performs dependency injection.**
- **Beans**
  - A Spring Bean is simply a Java object that is
    - Instantiated by spring
    - Configured by spring
    - Managed throughout its life cycle by spring
  - Beans forms the backbone of a spring application and are the code building locks that are wired together to create the application.
  - In simple terms --- **A Spring Bean is an object that Spring creates and manages inside the ApplicationContext.**
  - Analogy:
    - Think of the IoC container as a restaurant kitchen:
    - You (developer) write the recipe (class definitions).
    - Spring (IoC container) cooks the dishes (creates objects).
    - Spring serves the dishes wherever needed (dependency injection).
  - Classes annotated with the following annotations will automatically become **Spring Bean**:
    - @Component
    - @Service
    - @Repository
    - @Controller
    - @RestController
  - If you want a class should be managed by Spring only; you don't want to handle that by your own, then use @**Component** *annotation*.

```
@Component  1 usage
public class PaymentService {
    public void pay() {  1 usage
        System.out.println("Paying...");
    }
}
```

- It is the **bean**. We created the bean now. But still we need to inject it.

- To inject the **bean**, use the **@Autowired** annotation.

```
@Autowired  1 usage
PaymentService paymentServiceObj;
```

- **@Autowired** tells *Spring*: "Give me the bean for this dependency from the IoC container."

```
@Autowired  1 usage
PaymentService paymentServiceObj;

public static void main(String[] args) {
    SpringApplication.run(Module1IntroductionApplication.class, args);
}

@Override
public void run(String... args) throws Exception {
    paymentServiceObj.pay();
}
```

- You can see here, we didn't initialize the **paymentServiceObj** by our own. But it works because Spring created the bean (@Component) and it was injected here (@Autowired).

➢ There is an interface **CommandLineRunner** which is an *functional interface* containing one abstract function **run**.

- This **run** method is executed by **Spring framework** by it self after all the **beans** are created.
- **CommandLineRunner** in Spring Boot is a functional interface that lets you run some code immediately after the Spring Boot application starts, right after the *ApplicationContext* is fully initialized.

- Lets say you want to take control of the method of creation of Beans (Spring managed Objects).
  - Lets say the Class (out of which Bean will be created by Spring) is having some parameterized constructor and you want to take control and saying Spring that you need to pass this and that Object while creating the Bean (or creating the Object) of this class.
  - In this case you need to create one class using the annotation **@Configuration**.
  - The class having **@Configuration** will be treated as the **Bean** creation rule-book.
  - Inside this class, write methods which will return the Object of the particular classes you want to make Bean from. (classes means those Bean classes).
  - These methods should be written with the annotation **@Bean**.
  - 
```
@Configuration  no usages
public class AppConfig {

    @Bean  no usages
    public PaymentService paymentService() {
        System.out.println("customized bean creation");
        return new PaymentService();
    }
}
```
    - Here I don't have any parameterized constructor, I just gave example of how to customize creation of Beans.
  - **NOTE:**
    - You are taking control of only the way of creation. Creation & Injection will be handled by Spring only.
    - No need of giving annotations like @Component, @Service ..etc before the Bean class (class from which beans will be created. here: PaymentService class) when you are creating bean with **@Configuration** and **@Bean** annotation.
      - Even if those annotation is there, **@Bean** will override those.
- **Bean Life-cycle**
  - *Bean Created ==> Dependency Injected ==> Bean Initialized ===> Bean is Used ===> Bean is Destroyed*
  - 2 Bean life-cycle methods are there: **@PostConstruct**, **@PreDestroy**.
  - As the name suggests, **@PostConstruct** will be called right after the **Bean** is initialized (between *bean initialized* and *bean is used*).

- **@PreDestroy** is called after the bean being used and before destroying the bean. (between *bean is used* and *bean is destroyed*)

```
public class PaymentService {  3 usages
    public void pay() {  1 usage
        System.out.println("Paying...");
    }

    @PostConstruct  no usages
    public void postConstruct() {
        System.out.println("Post Construct");
    }

    @PreDestroy  no usages
    public void preDestroy() {
        System.out.println("Pre Destroy");
    }
}
```

- I added 2 methods using those *annotations* .

```
customized bean creation
Post Construct
2025-12-07T02:01:59.217+0
2025-12-07T02:01:59.225+0
Paying...
```

  - Customized bean creation was mentioned in the **@Bean** method.
- So you can see, the *Pre Destroy* is not called yet; because it is run before destroying the Bean.

```
customized bean creation
Post Construct
2025-12-07T02:01:59.217+0
2025-12-07T02:01:59.225+0
Paying...
2025-12-07T02:04:31.679+0
2025-12-07T02:04:31.692+0
Pre Destroy
```

  - I stopped the run and it was executed.

- **Bean Scope**
  - By default the bean scope is **Singleton** (one instance of bean will be created and shared everywhere).

```
@Autowired  1 usage
PaymentService paymentServiceObj;

@Autowired  1 usage
PaymentService paymentServiceObj2;

public static void main(String[] args) { SpringApplicat

@Override
public void run(String... args) throws Exception {
    System.out.println(paymentServiceObj.hashCode());
    System.out.println(paymentServiceObj2.hashCode());
```

  - Created 2 instance of this bean.

```
1843853990
1843853990
```

    - But if you see both are same. Because by default Spring created Singleton.
  - Now I am changing the scope to **prototype**.
    - It means it'll create one instance per object.

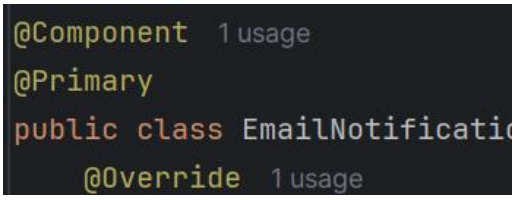
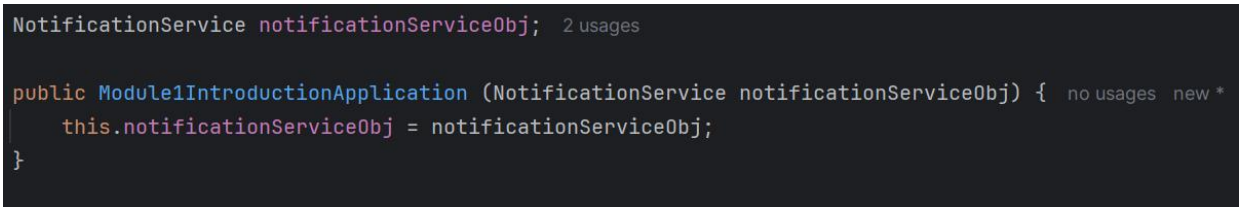
```
@Configuration  no usages
public class AppConfig {

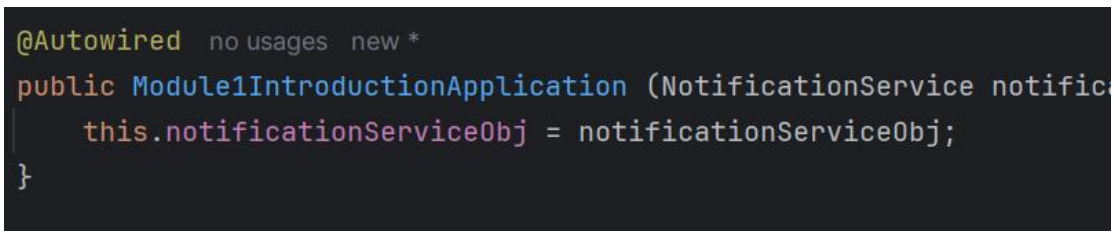
    @Bean  no usages
    @Scope("prototype")
    public PaymentService paymentService() {
        System.out.println("customized bean creation");
        return new PaymentService();
    }
}
```

    - You can write like this using the annotation **@Scope**

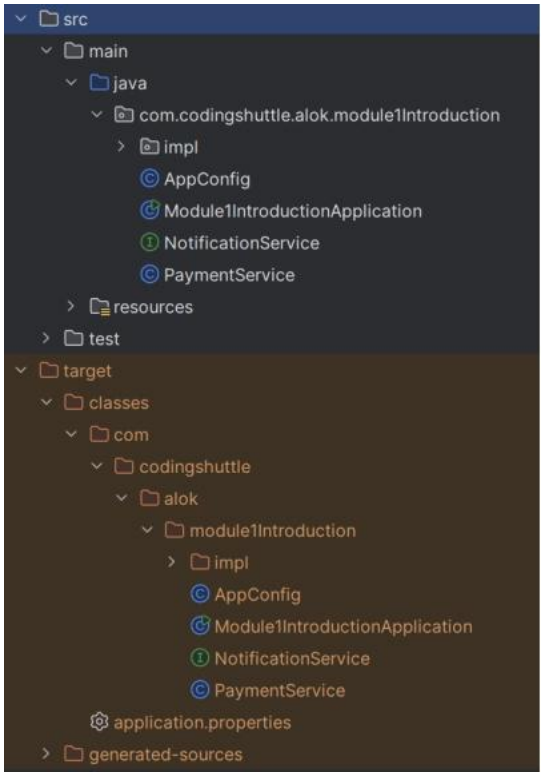
```
837249677
1997270773
```

    - Now the hashcodes are different because both are different beans.
  -

- **Dependency Injection**
  - **DI** is a design pattern where an object receives its dependencies from the outside, instead of creating them itself.
  - Lets say we have one interface **NotificationService**.
  - 2 classes are there which implement this interface: **EmailNotificationService**, **SmsNotificationService**.
  - Now we can create one object of type NotificationService and instantiate any type of NotificationService (either email or sms).
  - So, now lets make these classes as bean by adding the annotation **@Component**.
  - But now what will happen, Spring will be confused about which Bean (i.e. EmailNotificationService or SmsNotificationService) should be injected.
  - So for this, we can make one Class as **primary** so that when Spring will be having more than 1 option, it'll go ahead with the **Primary**.
  - 
    ```
    @Component  1 usage
    @Primary
    public class EmailNotificati
        @Override  1 usage
    ```
  - Before we were using **@Autowired** to inject the Bean. But that is not preferable because that is not safe.
  - It should be injected through the constructor.
  - 
    ```
    NotificationService notificationServiceObj;  2 usages

    public Module1IntroductionApplication (NotificationService notificationServiceObj) {  no usages  new *
        this.notificationServiceObj = notificationServiceObj;
    }
    ```
    - Here you can see, I have not mentioned **@Autowired** still it is working. Because by default, if the class is having only one constructor, then Spring will automatically treat that constructor like **@Autowired**
  - The above is same as below:
    - 
      ```
      @Autowired  no usages  new *
      public Module1IntroductionApplication (NotificationService notific
          this.notificationServiceObj = notificationServiceObj;
      }
      ```

- Types of dependency injection:
  - **Constructor ==> @Autowired** (optional) **==> Highly recommended**
  - **Setter ==> @Autowired** (required) **==> Ok ok**
  - **Field ==> @Autowired** (required) **==> Avoid in production**
- We were previously using the **Field** type of dependency injection.
- Lets say you have 2 similar Beans but you don't want to make anyone Primary (discussed above) then you can use **@Qualifier**
  - ```
    @Component  1 usage
    @Qualifier("email-notification")
    public class EmailNotificationService implements NotificationService {
    ```
  - ```
    public Module1IntroductionApplication (  no usages  new *
            @Qualifier("email-notification") NotificationService notificationServiceObj)
    ```
    - You can use the qualifier like this.
- You can also use conditional selection of Bean using **application.properties** file.
  - ```
    notification.type=email
    ```
    - Write some key value pair in *application.properties* file.
  - ```
    @Component  no usages
    @ConditionalOnProperty(name = "notification.type", havingValue = "sms")
    public class SmsNotificationService implements NotificationService {
    ```
  - In sms class: **@ConditionalOnProperty(name = "notification.type", havingValue = "sms")**
  - In Email class: **@ConditionalOnProperty(name = "notification.type", havingValue = "email")**
- Now no need of specifying the **@Qualifier** in the constructor. By default it'll take depending upon the value of *application.properties* file.
- If you want to inject all the beans i.e. if you want to send both **email** as well as **sms** then you can use **Map**
  - ```
    @Autowired  1 usage
    Map<String, NotificationService> notificationServiceMap = new HashMap<>();
    ```
  - ```
    @Autowired  1 usage
    Map<String, NotificationService> notificationServiceMap;
    ```
    - This one is more preferable.

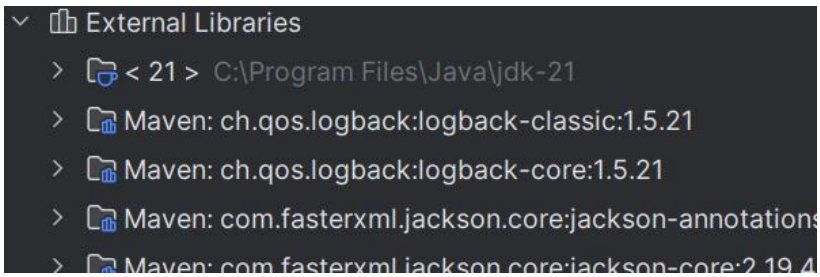
- **Classpath:**
  - The list of places where Java should look for **.class** files when running your program.
  - You can set the **classpath** by your own.
  - In my case it is there in **target/classes**
  - 

  - If you see here, **src** contains the **.java** files. **target/classes** contains the **.class** files.
  - Classpath DOES NOT include src/main/java. Why?
    - Because .java files are NOT executed by JVM.
    - Only bytecode (.class) is executed → so classpath always uses:
      - target/classes
      - external JARs
      - resource folders
- **Build path**
  - In short this is the **src** directory where **.java** files are present. Along with this the packages which are **.class** files (like ArrayList.class, Collections.class …etc).
  - Build path tells the IDE/compiler: *"Where should I look for **.java** files AND **library .class** files so I can compile your source code?"*
- **Build Path** = the list of places/tools the IDE (IntelliJ/Eclipse) uses to COMPILE your code.
- **Classpath** = the list of places the JVM uses to RUN your compiled code.

- **pom.xml**
  - It is used by spring to build the application.
  - ```
    <parent>
        <groupId>org.springframework.boot</groupId>
        <artifactId>spring-boot-starter-parent</artifactId>
        <version>3.5.8</version>
        <relativePath/> <!-- lookup parent from repository -->
    </parent>
    ```
  - You can see this type of **parent** dependency **spring-boot-starter-parent**.
  - ```
    <parent>
      <groupId>org.springframework.boot</groupId>
      <artifactId>spring-boot-dependencies</artifactId>
      <version>3.5.8</version>
    </parent>
    ```
  - When you open that **spring-boot-starter-parent**, you'll get one more **parent** in that **parent** xml file.
  - If you again go to this parent xml file, you'll find the following:
    - ```
      <properties>
        <activemq.version>6.1.8</activemq.version>
        <angus-mail.version>2.0.5</angus-mail.version>
        <artemis.version>2.40.0</artemis.version>
        <aspectj.version>1.9.25</aspectj.version>
        <assertj.version>3.27.6</assertj.version>
        <awaitility.version>4.2.2</awaitility.version>
      ```
    - Here you can find a lot of dependencies.
    - Spring maintains the versions of these dependencies; we don't have to manage the versions of the dependencies when we pull those dependencies.
    - These are **springboot starters dependencies**.
  - Maven is a popular build automation tool used in many Java projects. In a spring boot project, dependencies are specified in the pom.xml. Maven then resolves these dependencies and includes them n the classpath.
    - First it'll go inside the **pom.xml**
    - It'll go to all the parent dependencies till parents are present.
    - At the end, it'll get to know about the versions which it has to fetch. (the above image **<properties>**)
      ```

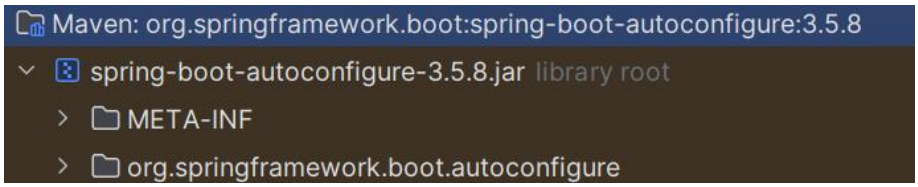
- Then it loads the dependencies that are required by Springboot application inside **classpath.**

- Starters like spring-boot-starter-parent include a ton of third-party libraries into your project - by default. Its AutoConfigurations use these dependencies to setup and preconfigure these libraries automatically.
  - It dig through all the dependencies file (if parents are there it'll go to the end and for every dependencies it'll do that), and then fetch all the dependencies and store in the **"External Libraries"** folder.

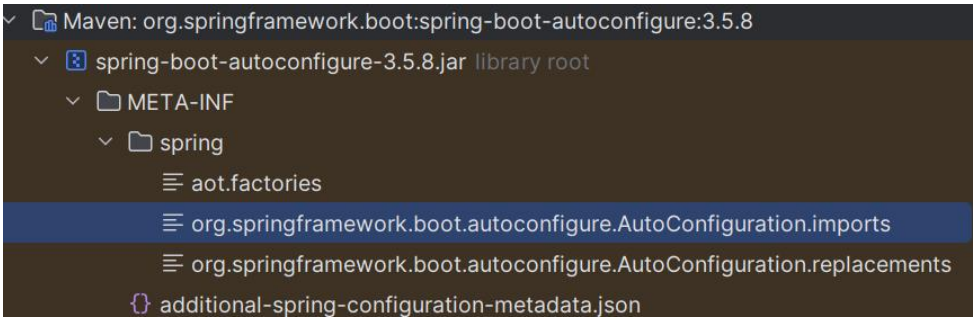


  - For example, if the **spring-boot-starter-parent** is added, then all the dependencies to which this is dependent will also be added.

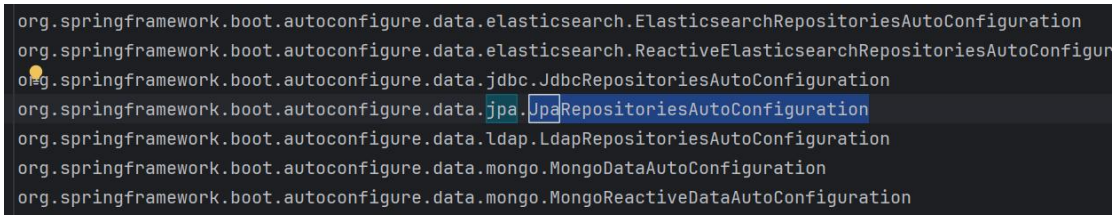
- There is one package inside the **External Libraries** foldere which is **autoconfigure.**



➢ Inside that **autoconfigure** package you'll find one **Autoconfiguration.imports** file.



- Here all the dependencies that Springboot will gonna auto-configure are mentioned.
  - **It contains fully qualified class names of auto-configuration classes.**



- I opened that **jpa** auto-configure class file and inside which multiple **conditionals** are there. When **all** the conditions becomes **true** then only **Bean** will be created out of this class.

```
@AutoConfiguration(  6 usages
        after = {HibernateJpaAutoConfiguration.c
)
@ConditionalOnBean({DataSource.class})
@ConditionalOnClass({JpaRepository.class})
@ConditionalOnMissingBean({JpaRepositoryFactoryB
@ConditionalOnBooleanProperty(
        name = {"spring.data.jpa.repositories.en
        matchIfMissing = true
)
@Import({JpaRepositoriesImportSelector.class})
public class JpaRepositoriesAutoConfiguration {
    @Bean
```

  - Lets say one **class** name is there in the **Autoconfigure.imports** but the **.class** file is not there in the *classpath*.
    - In this case, due to **@ConditionalOnClass**, Spring Boot simply skips that *auto-configuration* and does NOT create its beans.

- How Autoconfiguration works?
  - Classpath Scanning
    - Spring boot scans the classpath for the presence of certain libraries and classes.
    - Based on what it finds, it applies corresponding configurations.
  - Configuration Classes
    - Spring boot contains numerous autoconfiguration classes, each responsible for configuring a specific part of the application.
  - Conditional Beans
    - Each autoconfiguration class uses conditional checks to decide if it should be applied.
    - These conditions include the presence of specific classes, the absence of user-defined beans, and specific property settings.
- Enhanced Conditional Support
  - Spring boot comes with its own set of additional **@Conditional** annotations, which make developers' lives easier.

- **@ConditionalOnBean***(DataSource.class)*
  - This condition is true only if the user specified a DataSource *@Bean* in a configuration.
- **@ConditionalOnClass***(DataSource.class)*
  - This condition is true if the DataSource class is on the classpath.
- **@ConditionalOnProperty***("my.property")*
  - This condition is true if *my.property* is set.

- **@PropertySource**
  - It loads a **.properties** file into Spring's Environment, so that you can use the keys/values inside your classes.

```java
@Value("${key}")
```

```java
env.getProperty("key");
```

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