What is Dependency Injection

- Using Dependency Injection, we can makes our class independent of its dependencies.
- It helps to remove the dependency on concrete implementation and inject the dependencies from external source.

Let's see the Problem first:

```java
public class User {

    Order order = new Order();

    public User(){
        System.out.println("initializing user");
    }
}
```

```java
public class Order {

    public Order(){
        System.out.println("initializing Order");
    }
}
```

Issues with above class structure:

1. Both User and Order class are **Tightly coupled**.
   - Suppose, Order object creation logic gets changed *(lets say in future Object becomes an Interface and it has many concrete class)*, then USER class has to be changed too.

```java
public class User {

    Order order = new Order();   // new OnlineOrder();

    public User(){
        System.out.println("initializing user");
    }
}
```

```java
public interface Order {
}
```

```java
public class OnlineOrder implements Order{
}
```

```java
public class OfflineOrder implements Order{
}
```

2. It breaks **Dependency Inversion** rule of S.O.L.I.D principle
    i. This principle says that DO NOT depend on concrete implementation, rather depends on abstraction.

Breaks Dependency Inversion Principle (DIP)

```
public class User {

    Order order = new OnlineOrder();

    public User(){
        System.out.println("initializing user");
    }
}
```

Follows Dependency Inversion Principle (DIP)

```
public class User {

    Order order;

    public User(Order orderObj) {
        this.order = orderObj;
    }
}
```

Now in Spring boot how to achieve Dependency Inversion Principle?

Through Dependency Injection

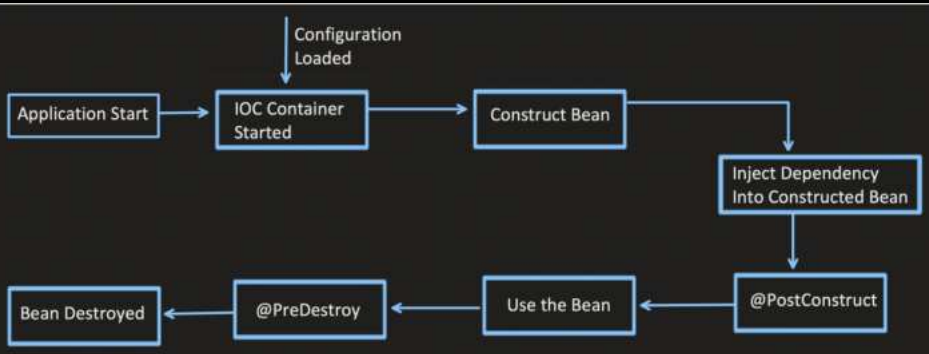
- Using Dependency Injection, we can makes our class independent of its dependencies.

- It helps to remove the dependency on concrete implementation and inject the dependencies from external source.

```
@Component
public class User {

    @Autowired
    Order order;

}
```

```
@Component
public class Order {
}
```

@Autowired, first look for a bean of the required type.
-> If bean found, Spring will inject it.



Different ways of Injection and which one is better?

- Field Injection
- Setter Injection
- Constructor Injection

Field Injection

- Dependency is set into the fields of the class directly.
- Spring uses reflection, it iterates over the fields and resolve the dependency.

```java
@Component
public class User {

    @Autowired
    Order order;

    public User() {
        System.out.println("User initialized");
    }
}
```

```java
@Component
@Lazy
public class Order {

    public Order(){
        System.out.println("order initialized");
    }
}
```

```
2024-04-13T21:33:30.390+05:30  INFO 20786 --- [           main] o.s.b.w.embedded.tomcat.TomcatWebServer  : Tomcat initialized with port 8080 (http)
2024-04-13T21:33:30.397+05:30  INFO 20786 --- [           main] o.apache.catalina.core.StandardService   : Starting service [Tomcat]
2024-04-13T21:33:30.397+05:30  INFO 20786 --- [           main] o.apache.catalina.core.StandardEngine    : Starting Servlet engine: [Apache Tomcat/10.1.19]
2024-04-13T21:33:30.425+05:30  INFO 20786 --- [           main] o.a.c.c.C.[Tomcat].[localhost].[/]       : Initializing Spring embedded WebApplicationContext
2024-04-13T21:33:30.425+05:30  INFO 20786 --- [           main] w.s.c.ServletWebServerApplicationContext : Root WebApplicationContext: initialization completed in 445 ms
User initialized
order initialized
2024-04-13T21:33:30.593+05:30  INFO 20786 --- [           main] o.s.b.w.embedded.tomcat.TomcatWebServer  : Tomcat started on port 8080 (http) with context path ''
2024-04-13T21:33:30.598+05:30  INFO 20786 --- [           main] c.c.l.SpringbootApplication              : Started SpringbootApplication in 0.811 seconds (process running for 0.983)
```

Advantage:

- Very simple and easy to use.

Disadvantage:

- Can not be used with Immutable fields.

```
@Component
public class User {

    @Autowired
    public final Order order;

    public User() {
        System.out.println("User initialized");
    }
}
```

- Chances of NPE

```
@Component
public class User {

    @Autowired
    public Order order;

    public User() {
        System.out.println("User initialized");
    }

    public void process(){
        order.process();
    }
}
```

```
User userObj = new User();
userObj.process();
```

```
Exception in thread "main" java.lang.NullPointerException Create breakpoint :
    at com.conceptandcoding.learningspringboot.User.process(User.java:18)
```

- During Unit Testing, setting MOCK dependency to this field becomes difficult.

```java
@Component
public class User {

    @Autowired
    private Order order;

    public User() {
        System.out.println("User initialized");
    }

    public void process(){
        order.process();
    }
}
```

```java
class UserTest {

private Order orderMockObj;

private User user;

    @BeforeEach
    public void setup(){
        this.orderMockObj = Mockito.mock(Order.class);
        this.user = new User();
    }
}
```

How to set this MOCK, we have to use reflection like @InjectMock annotation internally uses

```java
class UserTest {

@Mock
private Order orderMockObj;

@InjectMocks
private User user;

    @BeforeEach
    public void setup() {
        MockitoAnnotations.initMocks(this);
    }
}
```

Setter Injection

- Dependency is set into the fields using the setter method.
- We have to annotate the method using @Autowired

```java
@Component
public class User {

    public Order order;

    public User() {
        System.out.println("User initialized");
    }

    @Autowired
    public void setOrderDependency(Order order){
        this.order = order;
    }
}
```

```java
@Component
@Lazy
public class Order {

    public Order(){
        System.out.println("order initialized");
    }
}
```

Advantage:

- Dependency can be changed any time after the object creation (as object can not be marked as final).
- Ease of testing, as we can pass mock object in the dependency easily.

Disadvantage:

- Field Can not be marked as final. (We can not make it immutable).

```java
@Component
public class User {

    public final Order order;

    public User() {
        System.out.println("User initialized");
    }

    @Autowired
    public void setOrderDependency(Order order){
        this.order = order;
    }
}
```

- Difficult to read and maintained, as per standard, object should be initialized during object creation, so this might create code readability issue.

Constructor Injection

- Dependency get resolved at the time of initialization of the Object itself.
- Its recommended to use

```java
@Component
public class User {

    Order order;

    @Autowired
    public User(Order order) {
        this.order = order;
        System.out.println("User initialized");
    }

}
```

```java
@Component
@Lazy
public class Order {

    public Order(){
        System.out.println("order initialized");
    }
}
```

```
2024-04-13T21:08:45.923+05:30  INFO 19992 --- [           main] o.s.b.w.embedded.tomcat.TomcatWebServer  : Tomcat initialized with port 8080 (http)
2024-04-13T21:08:45.929+05:30  INFO 19992 --- [           main] o.apache.catalina.core.StandardService   : Starting service [Tomcat]
2024-04-13T21:08:45.929+05:30  INFO 19992 --- [           main] o.apache.catalina.core.StandardEngine    : Starting Servlet engine: [Apache Tomcat/10.1.19]
2024-04-13T21:08:45.955+05:30  INFO 19992 --- [           main] o.a.c.c.C.[Tomcat].[localhost].[/]       : Initializing Spring embedded WebApplicationContext
2024-04-13T21:08:45.955+05:30  INFO 19992 --- [           main] w.s.c.ServletWebServerApplicationContext : Root WebApplicationContext: initialization completed in 422 ms
order initialized
User initialized
2024-04-13T21:08:46.101+05:30  INFO 19992 --- [           main] o.s.b.w.embedded.tomcat.TomcatWebServer  : Tomcat started on port 8080 (http) with context path ''
2024-04-13T21:08:46.105+05:30  INFO 19992 --- [           main] c.c.l.SpringbootApplication              : Started SpringbootApplication in 0.759 seconds (process running for 0.932)
```

When only 1 constructor is present, then using @Autowired on constructor is not mandatory. (from Spring version 4.3)

```java
@Component
public class User {

    Order order;

    public User(Order order ) {
        this.order = order;
        System.out.println("User initialized");
    }
}
```

```java
@Component
@Lazy
public class Order {

    public Order(){
        System.out.println("order initialized");
    }
}
```

```
2024-04-13T21:08:45.955+05:30  INFO 19992 --- [           main] o.a.c.c.C.[Tomcat].[localhost].[/]       : Initializing Spring embedded WebApplicationContext
2024-04-13T21:08:45.955+05:30  INFO 19992 --- [           main] w.s.c.ServletWebServerApplicationContext : Root WebApplicationContext: initialization completed in 422 ms
order initialized
User initialized
2024-04-13T21:08:46.101+05:30  INFO 19992 --- [           main] o.s.b.w.embedded.tomcat.TomcatWebServer  : Tomcat started on port 8080 (http) with context path ''
2024-04-13T21:08:46.105+05:30  INFO 19992 --- [           main] c.c.l.SpringbootApplication              : Started SpringbootApplication in 0.759 seconds (process running for 0.932)
```

When more than 1 constructor is present, then using @Autowired on constructor is mandatory.

```java
@Component
public class User {

    Order order;
    Invoice invoice;

    public User(Order order ) {
        this.order = order;
        System.out.println("User initialized with only Order");
    }

    public User(Invoice invoice) {
        this.invoice = invoice;
        System.out.println("User initialized with only Invoice");
    }
}
```

```java
@Component
@Lazy
public class Invoice {

    public Invoice() { System.out.println("invoice initialized"); }
}
```

```java
@Component
@Lazy
public class Order {

    public Order(){
        System.out.println("order initialized");
    }
}
```

Caused by: org.springframework.beans.BeanInstantiationException Create breakpoint : Failed to instantiate [com.conceptandcoding.learningspringboot.User]: No default constructor found

```java
@Component
public class User {

    Order order;
    Invoice invoice;

    public User(Order order ) {
        this.order = order;
        System.out.println("User initialized with only Order");
    }

    @Autowired
    public User(Invoice invoice) {
        this.invoice = invoice;
        System.out.println("User initialized with only Invoice");
    }
}
```

```java
@Component
@Lazy
public class Invoice {

    public Invoice() { System.out.println("invoice initialized"); }
}
```

```java
@Component
@Lazy
public class Order {

    public Order(){
        System.out.println("order initialized");
    }
}
```

```
2024-04-13T21:16:01.654+05:30  INFO 20242 --- [           main] o.apache.catalina.core.StandardService   : Starting service [Tomcat]
2024-04-13T21:16:01.654+05:30  INFO 20242 --- [           main] o.apache.catalina.core.StandardEngine    : Starting Servlet engine: [Apache Tomcat/10.1.19]
2024-04-13T21:16:01.676+05:30  INFO 20242 --- [           main] o.a.c.c.C.[Tomcat].[localhost].[/]       : Initializing Spring embedded WebApplicationContext
2024-04-13T21:16:01.677+05:30  INFO 20242 --- [           main] w.s.c.ServletWebServerApplicationContext : Root WebApplicationContext: initialization completed in 430 ms
invoice initialized
User initialized with only Invoice
2024-04-13T21:16:01.827+05:30  INFO 20242 --- [           main] o.s.b.w.embedded.tomcat.TomcatWebServer  : Tomcat started on port 8080 (http) with context path ''
2024-04-13T21:16:01.832+05:30  INFO 20242 --- [           main] c.c.l.SpringbootApplication              : Started SpringbootApplication in 0.775 seconds (process running for 0.94)
```

Why Constructor Injection is Recommended (Advantages):

1. All mandatory dependencies are created at the time of initialization itself. Makes 100% sure that our object is fully initialized with mandatory dependency
   i. avoid NPE during runtime
   ii. Unnecessary null checks can be avoided too.

2. We can create immutable object using Constructor injection.

```java
@Component
public class User {

    public final Order order ;

    @Autowired
    public User(Order order) {
        this.order = order;
        System.out.println("User initialized");
    }
}
```

```java
@Component
public class User {

    @Autowired
    public final Order order ;

    public User() {
        System.out.println("User initialized");
    }
}
```

3. Fail Fast: If there is any missing dependency, it will fail during compilation itself, rather than failing during run Time.

```java
@Component
public class User {

    public Order order;

    public User() {
        System.out.println("User initialized");
    }

    @PostConstruct
    public void init(){
        System.out.println(order == null);
    }
}
```

```java
@Component
public class Order {

    public Order(){
        System.out.println("order initialized");
    }
}
```

Using Constructor Injection, even if we missed @Autowired

```java
@Component
public class User {

    public Order order;

    public User(Order order) {
        this.order = order;
        System.out.println("User initialized");
    }

    @PostConstruct
    public void init(){
        System.out.println(order == null);
    }
}
```

OR

(it will fail fast, if Order bean is missing)

```java
@Component
public class User {

    public Order order;

    public User(Order order) {
        this.order = order;
        System.out.println("User initialized");
    }

    @PostConstruct
    public void init(){
        System.out.println(order == null);
    }
}
```

```java
public class Order {

    public Order(){
        System.out.println("order initialized");
    }
}
```

```
***************************
APPLICATION FAILED TO START
***************************

Description:

Parameter 0 of constructor in com.conceptandcoding.learningspringboot.User required a bean of type 'com.conceptandcoding.learningspringboot.Order' that could not be found.
```

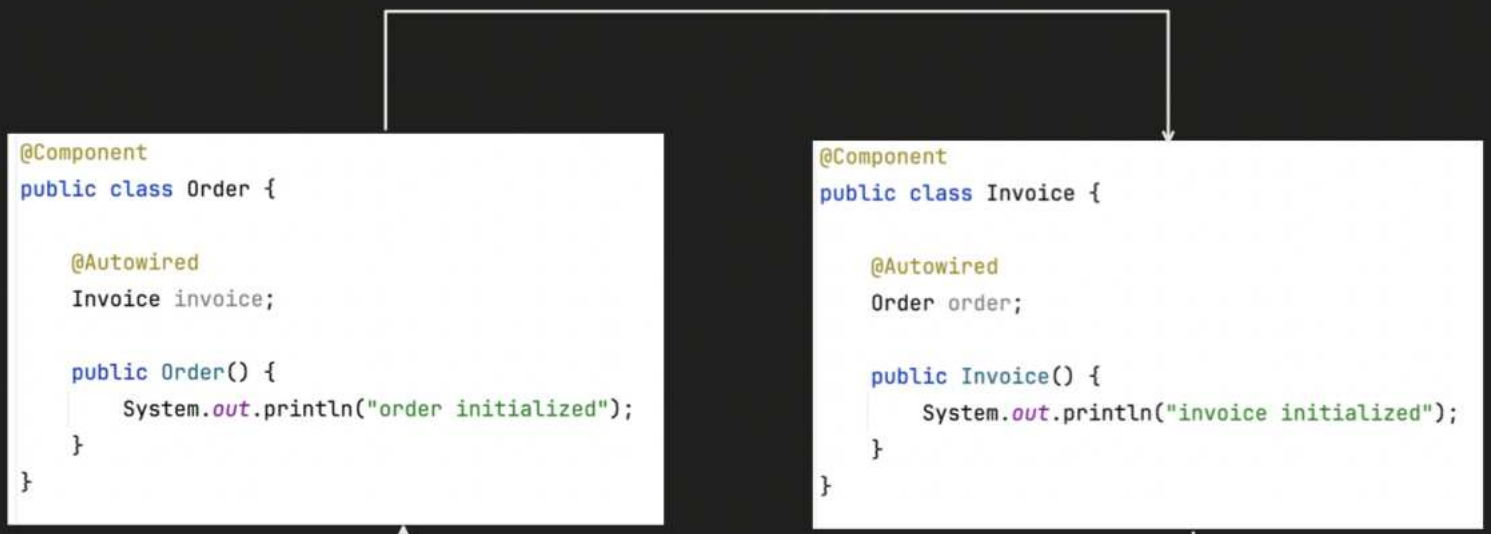
4. Unit testing is easy.

```java
@Component
public class User {

    private Order order;

    @Autowired
    public User(Order order) {
        this.order = order;
        System.out.println("User initialized");
    }

    public void process(){
        order.process();
    }
}
```

```java
class UserTest {

private Order orderMockObj;

private User user;

    @BeforeEach
    public void setup(){
        this.orderMockObj = Mockito.mock(Order.class);
        this.user = new User(orderMockObj);
    }
}
```

Common Issues when dealing with Dependency Injection:

1. CIRCULAR DEPENDENCY



```java
@Component
public class Order {

    @Autowired
    Invoice invoice;

    public Order() {
        System.out.println("order initialized");
    }
}
```

```java
@Component
public class Invoice {

    @Autowired
    Order order;

    public Invoice() {
        System.out.println("invoice initialized");
    }
}
```

```
***************************
APPLICATION FAILED TO START
***************************

Description:

The dependencies of some of the beans in the application context form a cycle:

┌─────┐
|  invoice
↑     ↓
|  order
└─────┘
```

Solutions:

1. First and foremost, can we refactor the code and remove this cycle dependency:

For example, common code in which both are dependent, can be taken out to separate class. This way we can break the circular dependency.

2. Using @Lazy on @Autowired annotation .

Spring will create proxy bean instead of creating the bean instance immediately during application startup.

@Lazy on field Injection

Let's first consider this

```java
@Component
@Lazy
public class Order {

    public Order() {
        System.out.println("Order initialized");
    }
}
```

```java
@Component
public class Invoice {

    @Autowired
    public Order order;

    public Invoice() {
        System.out.println("Invoice initialized");
    }
}
```

```
2024-04-14T18:21:55.967+05:30  INFO 48155 --- [           main] o.apache.catalina.core.StandardService   : Starting service [Tomcat]
2024-04-14T18:21:55.967+05:30  INFO 48155 --- [           main] o.apache.catalina.core.StandardEngine    : Starting Servlet engine: [Apache Tomcat/10.1.19]
2024-04-14T18:21:55.993+05:30  INFO 48155 --- [           main] o.a.c.c.C.[Tomcat].[localhost].[/]       : Initializing Spring embedded WebApplicationContext
2024-04-14T18:21:55.993+05:30  INFO 48155 --- [           main] w.s.c.ServletWebServerApplicationContext : Root WebApplicationContext: initialization completed in 438 ms
Invoice initialized
Order initialized
2024-04-14T18:21:56.141+05:30  INFO 48155 --- [           main] o.s.b.w.embedded.tomcat.TomcatWebServer  : Tomcat started on port 8080 (http) with context path ''
2024-04-14T18:21:56.146+05:30  INFO 48155 --- [           main] c.c.l.SpringbootApplication              : Started SpringbootApplication in 0.778 seconds (process running for 0.967)
```

Now, lets see this:

```java
@Component
@Lazy
public class Order {

    public Order() {
        System.out.println("Order initialized");
    }
}
```

```java
@Component
public class Invoice {

    @Lazy
    @Autowired
    public Order order;

    public Invoice() {
        System.out.println("Invoice initialized");
    }
}
```

```
2024-04-14T18:24:03.474+05:30  INFO 48250 --- [           main] o.s.b.w.embedded.tomcat.TomcatWebServer  : Tomcat initialized with port 8080 (http)
2024-04-14T18:24:03.482+05:30  INFO 48250 --- [           main] o.apache.catalina.core.StandardService   : Starting service [Tomcat]
2024-04-14T18:24:03.482+05:30  INFO 48250 --- [           main] o.apache.catalina.core.StandardEngine    : Starting Servlet engine: [Apache Tomcat/10.1.19]
2024-04-14T18:24:03.507+05:30  INFO 48250 --- [           main] o.a.c.c.C.[Tomcat].[localhost].[/]       : Initializing Spring embedded WebApplicationContext
2024-04-14T18:24:03.507+05:30  INFO 48250 --- [           main] w.s.c.ServletWebServerApplicationContext : Root WebApplicationContext: initialization completed in 426 ms
Invoice initialized
2024-04-14T18:24:03.677+05:30  INFO 48250 --- [           main] o.s.b.w.embedded.tomcat.TomcatWebServer  : Tomcat started on port 8080 (http) with context path ''
2024-04-14T18:24:03.683+05:30  INFO 48250 --- [           main] c.c.l.SpringbootApplication              : Started SpringbootApplication in 0.792 seconds (process running for 0.96)
```

Now, We can use this @Lazy to resolve the circular dependency

```java
@Component
public class Order {

    @Autowired
    Invoice invoice;

    public Order() {
        System.out.println("order initialized");
    }
}
```

```java
@Component
public class Invoice {

    @Lazy
    @Autowired
    public Order order;

    public Invoice() {
        System.out.println("Invoice initialized");
    }
}
```

```
2024-04-14T18:27:04.567+05:30  INFO 48425 --- [           main] o.apache.catalina.core.StandardService   : Starting service [Tomcat]
2024-04-14T18:27:04.568+05:30  INFO 48425 --- [           main] o.apache.catalina.core.StandardEngine    : Starting Servlet engine: [Apache Tomcat/10.1.19]
2024-04-14T18:27:04.591+05:30  INFO 48425 --- [           main] o.a.c.c.C.[Tomcat].[localhost].[/]       : Initializing Spring embedded WebApplicationContext
2024-04-14T18:27:04.592+05:30  INFO 48425 --- [           main] w.s.c.ServletWebServerApplicationContext : Root WebApplicationContext: initialization completed in 432 ms
Invoice initialized
Order initialized
2024-04-14T18:27:04.745+05:30  INFO 48425 --- [           main] o.s.b.w.embedded.tomcat.TomcatWebServer  : Tomcat started on port 8080 (http) with context path ''
2024-04-14T18:27:04.750+05:30  INFO 48425 --- [           main] c.c.l.SpringbootApplication              : Started SpringbootApplication in 0.784 seconds (process running for 0.958)
```

3. Using @PostConstruct

```java
@Component
public class Order {

    @Autowired
    Invoice invoice;

    public Order() {
        System.out.println("Order initialized");
    }

    @PostConstruct
    public void initialize(){
        invoice.setOrder(this);
    }
}
```

```java
@Component
public class Invoice {

    public Order order;

    public Invoice() {
        System.out.println("Invoice initialized");
    }

    public void setOrder(Order order) {
        this.order = order;
    }
}
```

```
2024-04-14T18:27:04.567+05:30  INFO 48425 --- [           main] o.apache.catalina.core.StandardService   : Starting service [Tomcat]
2024-04-14T18:27:04.568+05:30  INFO 48425 --- [           main] o.apache.catalina.core.StandardEngine    : Starting Servlet engine: [Apache Tomcat/10.1.19]
2024-04-14T18:27:04.591+05:30  INFO 48425 --- [           main] o.a.c.c.C.[Tomcat].[localhost].[/]       : Initializing Spring embedded WebApplicationContext
2024-04-14T18:27:04.592+05:30  INFO 48425 --- [           main] w.s.c.ServletWebServerApplicationContext : Root WebApplicationContext: initialization completed in 432 ms
Invoice initialized
Order initialized
2024-04-14T18:27:04.745+05:30  INFO 48425 --- [           main] o.s.b.w.embedded.tomcat.TomcatWebServer  : Tomcat started on port 8080 (http) with context path ''
2024-04-14T18:27:04.750+05:30  INFO 48425 --- [           main] c.c.l.SpringbootApplication              : Started SpringbootApplication in 0.784 seconds (process running for 0.958)
```

UNSATISFIED DEPENDENCY

Problem:

```java
@Component
public class User {

    @Autowired
    Order order;

    public User() {
        System.out.println("User initialized");
    }
}
```

```java
public interface Order {
}
```

```java
@Component
public class OnlineOrder implements Order {

    public OnlineOrder() {
        System.out.println("Online order initialized");
    }
}
```

```java
@Component
public class OfflineOrder implements Order{

    public OfflineOrder() {
        System.out.println("Offline order initialized");
    }
}
```

```
***************************
APPLICATION FAILED TO START
***************************
```

```
UnsatisfiedDependencyException: Error creating bean with name 'user'
```

Solution:

1. @Primary annotation

```java
@Component
public class User {

    @Autowired
    Order order;

    public User() {
        System.out.println("User initialized");
    }
}
```

```java
public interface Order {
}
```

```java
@Primary
@Component
public class OnlineOrder implements Order {

    public OnlineOrder() {
        System.out.println("Online order initialized");
    }
}
```

```java
@Component
public class OfflineOrder implements Order{

    public OfflineOrder() {
        System.out.println("Offline order initialized");
    }
}
```

```
2024-04-14T19:09:38.705+05:30  INFO 51207 --- [           main] o.apache.catalina.core.StandardEngine    : Starting Servlet engine: [Apache Tomcat/10.1.19]
2024-04-14T19:09:38.729+05:30  INFO 51207 --- [           main] o.a.c.c.C.[Tomcat].[localhost].[/]       : Initializing Spring embedded WebApplicationContext
2024-04-14T19:09:38.729+05:30  INFO 51207 --- [           main] w.s.c.ServletWebServerApplicationContext : Root WebApplicationContext: initialization completed in 417 ms
Offline order initialized
Online order initialized
User initialized
2024-04-14T19:09:38.882+05:30  INFO 51207 --- [           main] o.s.b.w.embedded.tomcat.TomcatWebServer  : Tomcat started on port 8080 (http) with context path ''
2024-04-14T19:09:38.887+05:30  INFO 51207 --- [           main] c.c.l.SpringbootApplication              : Started SpringbootApplication in 0.763 seconds (process running for 0.927)
```

2. @Qualifier annotation

```java
@Component
public class User {

    @Qualifier("offlineOrderName")
    @Autowired
    Order order;

    public User() {
        System.out.println("User initialized");
    }
}
```

```java
public interface Order {
}
```

```java
@Component
@Qualifier("onlineOrderName")
public class OnlineOrder implements Order {

    public OnlineOrder() {
        System.out.println("Online order initialized");
    }
}
```

```java
@Component
@Qualifier("offlineOrderName")
public class OfflineOrder implements Order{

    public OfflineOrder() {
        System.out.println("Offline order initialized");
    }
}
```

```
2024-04-14T19:16:15.633+05:30  INFO 51489 --- [           main] o.apache.catalina.core.StandardService   : Starting service [Tomcat]
2024-04-14T19:16:15.633+05:30  INFO 51489 --- [           main] o.apache.catalina.core.StandardEngine    : Starting Servlet engine: [Apache Tomcat/10.1.19]
2024-04-14T19:16:15.657+05:30  INFO 51489 --- [           main] o.a.c.c.C.[Tomcat].[localhost].[/]       : Initializing Spring embedded WebApplicationContext
2024-04-14T19:16:15.657+05:30  INFO 51489 --- [           main] w.s.c.ServletWebServerApplicationContext : Root WebApplicationContext: initialization completed in 419 ms
Offline order initialized
Online order initialized
User initialized
2024-04-14T19:16:15.807+05:30  INFO 51489 --- [           main] o.s.b.w.embedded.tomcat.TomcatWebServer  : Tomcat started on port 8080 (http) with context path ''
2024-04-14T19:16:15.813+05:30  INFO 51489 --- [           main] c.c.l.SpringbootApplication              : Started SpringbootApplication in 0.763 seconds (process running for 0.932)
```