

1 Sources

- <https://redips789.github.io/spring-certification/Spring-Certification.html>
- <https://www.baeldung.com/inversion-control-and-dependency-injection-in-spring>
- <https://www.baeldung.com/inversion-control-and-dependency-injection-in-spring>
- <https://www.baeldung.com/spring-bean-names>
- <https://www.baeldung.com/spring-core-annotations>
- <https://www.baeldung.com/spring-bean-annotations>
- <https://www.baeldung.com/spring-component-scanning>
- <https://www.baeldung.com/spring-annotations-resource-inject-autowire>
- <https://www.digitalocean.com/community/tutorials/spring-bean-life-cycle>

2 Bean Lifecycle

2.1 Overview

From a bird's eye, everything that happens before a bean is ready to use can be assigned to one of three phases (see fig. 1):

- Loading and maybe modifying bean definitions
- Instantiating beans
- Initializing beans

Figure 2 focuses on pre-initialization.

On the other hand, fig. 4 zooms in on post-instantiation.

See <https://www.digitalocean.com/community/tutorials/spring-bean-life-cycle> for code to display the order of invocations.

2.1.1 Load bean definitions, creating an ordered graph

In this step, all the configuration files – @Configuration classes or XML files – are processed. For annotation-based configuration, all the classes annotated with @Components are scanned to load the bean definitions.

Bean definitions are passed to a BeanFactory, each under its id and type. For example, ApplicationContext is a BeanFactory.

Then, BeanFactoryPostProcessors are run.

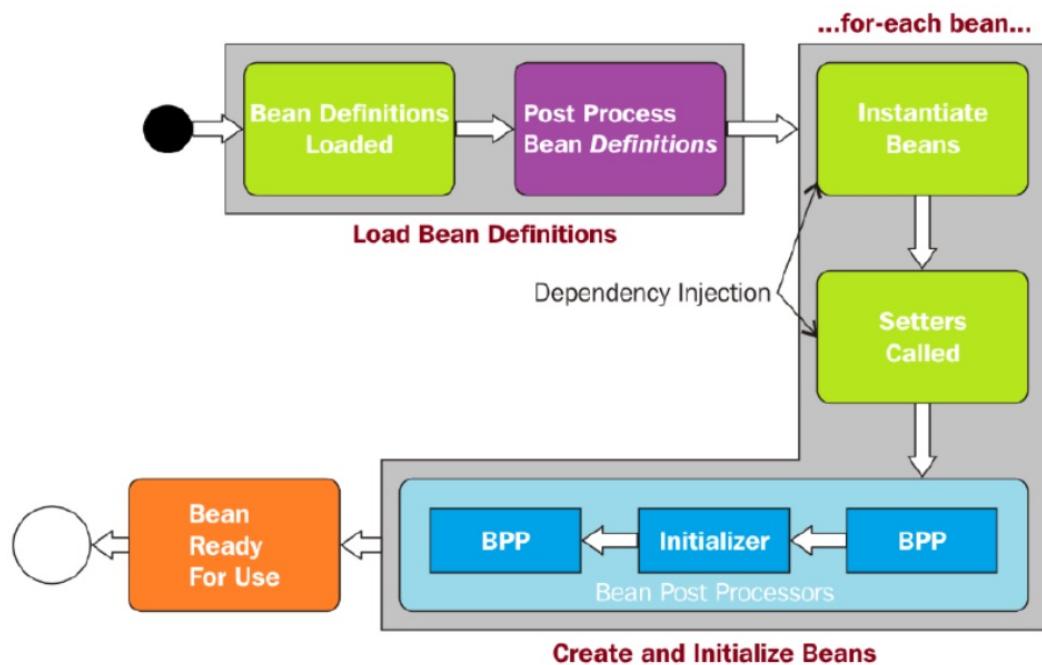


Figure 1: Lifecycle overview

Configuration Lifecycle

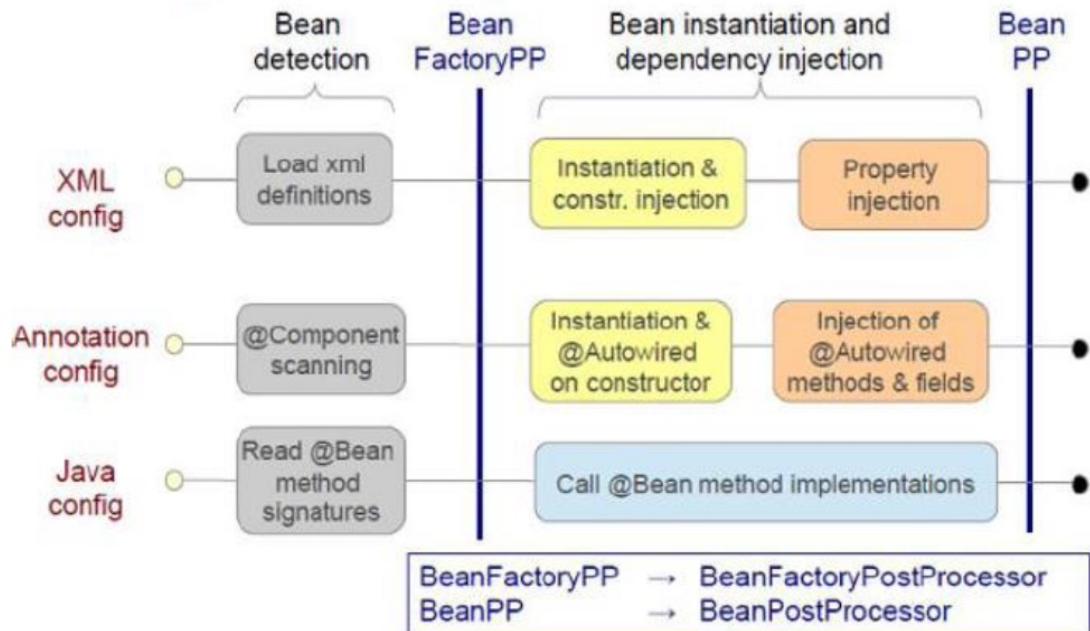


Figure 2: Zooming in on pre-instantiation

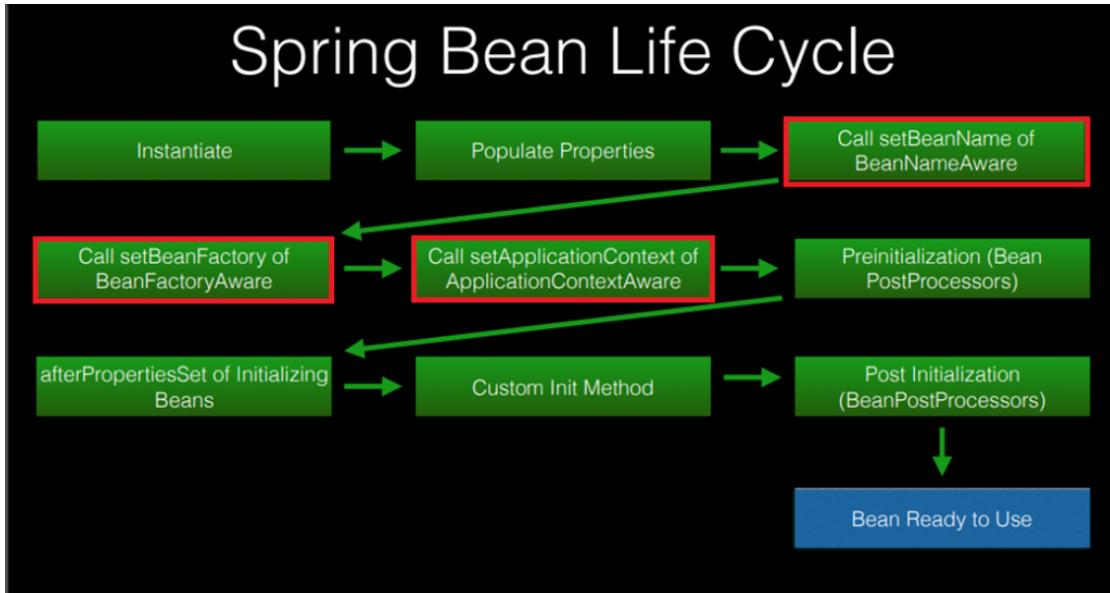


Figure 3: Zooming in on post-instantiation

2.1.2 Instantiate and run BeanFactoryPostProcessors

In a Spring application, a BeanFactoryPostProcessor can modify the definition of any bean. The BeanFactory object is passed as an argument to the postProcess() method of the BeanFactoryPostProcessor. BeanFactoryPostProcessor then works on the bean definitions or the configuration metadata of the bean before the beans are actually created. Spring provides several useful implementations of BeanFactoryPostProcessor, such as reading properties and registering a custom scope. We can write your own implementation of the BeanFactoryPostProcessor interface. To influence the order in which bean factory post processors are invoked, their bean definition methods may be annotated with the @Order annotation. If you are implementing your own bean factory post processor, the implementation class can also implement the Ordered interface.

2.1.3 Instantiate beans

Injects values and bean references into beans' properties.

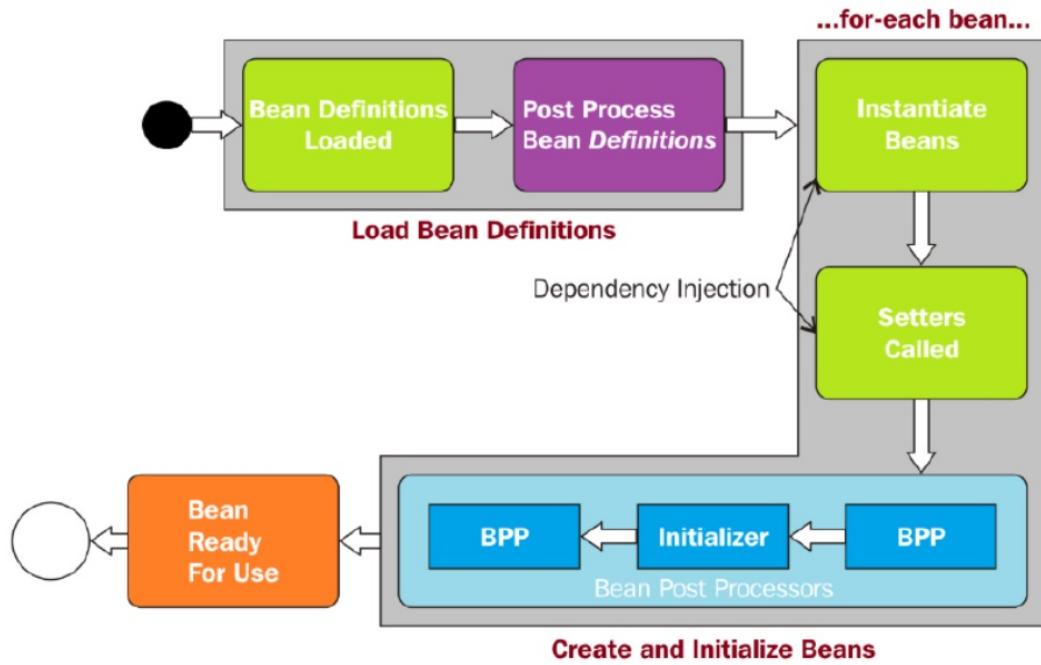


Figure 4:

- 2.1.4 Call **BeanNameAware's setBeanName()** for each bean implementing it
- 2.1.5 Call **BeanFactoryAware's setBeanFactory()** passing the bean factory for each bean implementing it
- 2.1.6 Call **ApplicationContextAware's setApplicationContext** for each bean implementing it
- 2.1.7 **Before initialization: Run pre-initialization BeanPostProcessors**

The Application context calls `postProcessBeforeInitialization()` for each bean implementing `BeanPostProcessor`.

```

1  public interface BeanPostProcessor {
2
3      /**
4       * Apply this {@code BeanPostProcessor} to the given new
5       * bean instance before any bean's initialization
6       * callbacks (like InitializingBean's afterPropertiesSet
7       * or a custom init-method).
8       */
9      @Nullable
10     default Object postProcessBeforeInitialization(Object
11         bean, String beanName) throws BeansException {

```

Example: CustomBeanPostProcessor

```
@Component ← Can be found by component-scanner, like any other bean
public class CustomBeanPostProcessor implements BeanPostProcessor {

    public Object postProcessBeforeInitialization(Object bean, String beanName) {
        // Some code
        return bean; // Remember to return your bean or you'll lose it!
    }

    public Object postProcessAfterInitialization(Object bean, String beanName) {
        // Some code
        return bean; // Remember to return your bean or you'll lose it!
    }
}
```

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Figure 5: Custom bean postprocessor

```
9         return bean;
10    }
11
12    /**
13     * Apply this {@code BeanPostProcessor} to the given new
14     * bean instance after any bean initialization
15     * callbacks (like InitializingBean's afterPropertiesSet
16     * or a custom init-method).
17     */
18    @Nullable
19    default Object postProcessAfterInitialization (Object
20        bean, String beanName) throws BeansException {
            return bean;
        }
    }
```

In postProcessBeforeInitialization and postProcessAfterInitialization, a bean implementing BeanPostProcessor can return anything it wants - even something completely different!

Figure 5 shows a no-op implementation.

2.1.8 Initialization: Call InitializingBean's afterPropertiesSet()

If a bean implements the InitializingBean interface, Spring calls its afterPropertiesSet() method. Used to initialize processes, load resources, etc. This approach is simple to use but it's not recommended because it will create tight coupling with the Spring framework in our bean implementations.

```
1 public interface InitializingBean {  
2  
3     /**  
4      * Invoked by the containing BeanFactory after it has set  
5      * all bean properties.  
6      * This method allows the bean instance to perform  
7      * validation of its overall configuration and final  
8      * initialization when all bean properties have been set.  
9     */  
10    void afterPropertiesSet() throws Exception;  
11 }  
12
```

2.1.9 Initialization: Init Method, @PostConstruct

Instead of implementing InitializingBean, you can use the init-method of the bean tag, the initMethod attribute of the @Bean annotation, and JSR 250's @PostConstruct annotation. Here we use the init-method attribute:

```
1 <bean name="myEmployeeService"  
2       class="com.journaldev.spring.service.MyEmployeeService"  
3       init-method="init" destroy-method="destroy">  
4       <property name="employee" ref="employee"></property>  
5     </bean>
```

Using init-method is a solution when you don't own the class (and so, can't annotate it).

And here, the @PostConstruct annotation.

```
1 @PostConstruct  
2 public void init(){  
3     System.out.println("MyService init method called");  
4 }
```

@PostConstruct and init-method are enabled by Spring's CommonAnnotationBeanPostProcessor. This is a BeanPostProcessor implementation that supports common Java

annotations out of the box, in particular the JSR-250 annotations in the javax.annotation package.

It includes support for the javax.annotation.PostConstruct and javax.annotation.PreDestroy annotations - as init annotation and destroy annotation, respectively - through inheriting from InitDestroyAnnotationBeanPostProcessor with pre-configured annotation types.

```
1  public class CommonAnnotationBeanPostProcessor extends  
2      InitDestroyAnnotationBeanPostProcessor  
3  implements InstantiationAwareBeanPostProcessor,  
4          BeanFactoryAware, Serializable { ... }
```

2.1.10 After initialization: Run post-initialization BeanPostProcessors

The application context calls postProcessAfterInitialization() for each bean implementing BeanPostProcessor.

2.1.11 Bean ready to use

Your beans remain live in the application context until it is closed by calling the close() method of the application context.

2.1.12 Custom destruction

If a bean implements the DisposableBean interface, Spring calls its destroy() method to destroy any process or clean up the resources of your application. There are other methods to achieve this step-for example, you can use the destroy-method of the tag, the destroyMethod attribute of the '@Bean' annotation, and JSR 250's '@PreDestroy' annotation.

3 Dependency injection

3.1 Constructor-based

In the case of constructor-based dependency injection, the container will invoke a constructor with arguments each representing a dependency we want to set. This is the recommended way.

```
1  @Configuration  
2  public class AppConfig {  
3      @Bean  
4      public Item item1() {  
5          return new ItemImpl1();  
6      }  
7      @Bean
```

```
8     public Store store() {
9         return new Store(item1());
10    }
11 }
```

Resp.

```
1 <bean id="item1" class="org.baeldung.store.ItemImpl1"
2   />
3 <bean id="store" class="org.baeldung.store.Store">
4   <constructor-arg type="ItemImpl1" index="0"
5     name="item" ref="item1" />
6 </bean>
```

3.2 Method-based

For setter-based DI, the container will call setter methods of our class after invoking a no-argument constructor or no-argument static factory method to instantiate the bean.

```
1 @Bean
2 public Store store() {
3     Store store = new Store();
4     store.setItem(item1());
5     return store;
6 }
```

Resp.

```
1 <bean id="store" class="org.baeldung.store.Store">
2   <property name="item" ref="item1" />
3 </bean>
```

3.3 Field-based

In field-based DI, we can inject the dependencies by marking them with an `@Autowired` annotation. (This even works for private fields.) Field-based injection is not recommended - e.g., it makes testing harder.

```
1 public class Store {
2     @Autowired // deprecated
3     private Item item;
```

```
4 } 
```

4 Configuration: Implicit vs. Explicit

Also referred to as Java-based (decoupled) and annotation-based.
with both types, bean naming works differently - see [7](#).

4.1 Java-based

Takes place completely in @Configuration classes. E.g.,

```
1 @Configuration  
2 public class MyConfig {  
3     @Bean  
4     public AccountRepo AccountRepo() {}  
5 }
```

4.2 Annotation-based

Bean definition and wiring take place completely in POJOs. For this to work, we need to enable component scanning.

```
1 @Configuration  
2 @ComponentScan  
3 public class MyConfig {}  
4  
5 @Component  
6 public class AccountRepo {} 
```

4.3 Spring Boot Auto-Configuration

When @EnableAutoConfiguration is present, beans annotated with @AutoConfiguration will be configured.

In `spring-boot-autoconfigure.jar`, `/META-INF/spring/org.springframework.boot.autoconfigure.AutoConfigure` lists the classes by default autoconfigured by Spring.

Spring's `DataSourceAutoConfiguration` class is one example. See fig. [6](#).

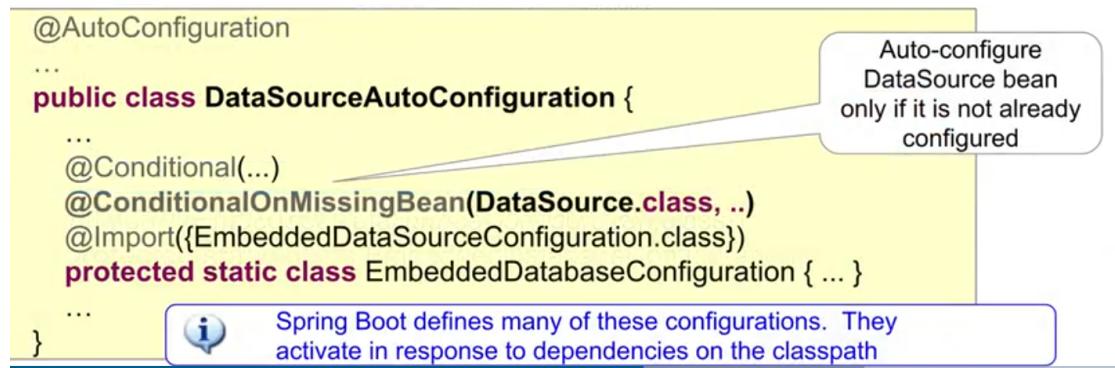


Figure 6: Spring's `DataSourceAutoConfiguration` class.

5 Annotations

5.1 Annotations for dependency injection

5.1.1 `@Autowired`

`@Autowired` marks a dependency which Spring is going to resolve and inject. We can use this annotation with constructor, setter, or field injection. E.g.,

```

1   class Car {
2       @Autowired
3       Engine engine;
4   }

```

Starting with version 4.3, we don't need to annotate constructors with `@Autowired` explicitly unless we declare at least two constructors.

`@Autowired` matches by type. If there are several classes matching the required type (e.g., implementing the same interface), `@Autowired` needs to be supplemented by `@Qualifier`:

```

1   @Component("Repo1")
2   class Repo1 implements Repo {}
3
4   @Component("Repo2")
5   class Repo2 implements Repo {}
6
7   @Component
8   public class Service1 implements ServiceX {
9       public Service1(@Qualifier("Repo2") Repo) {}
10

```

```
11 }
```

If there is no @Qualifier given, @Autowired looks for a matching bean name (= bean id). Here, Spring will look for a bean named x:

```
1 // constructor injection
2 @Autowired
3 public MyBean(X x){}
4
5 // method injection
6 @Autowired
7 public setX(X x){}
8
9 // field injection
10 @Autowired
11 private X x;
```

5.1.2 @Bean

@Bean marks a factory method which instantiates a Spring bean.

```
1 @Bean
2     Engine engine() {
3         return new Engine();
4     }
```

Spring calls these methods when a new instance of the return type is required. All methods annotated with @Bean must be in @Configuration classes.

5.1.3 @Resource

The @Resource annotation matches by name, type, or qualifier (in this order). It is applicable to setter and field injection. Here's an example injecting a field. Note that the bean id and the corresponding reference attribute value must match:

```
1 @Configuration
2 public class MyAppContext {
3     @Bean(name="namedFile")
4     public File namedFile() {
5         File namedFile = new File("namedFile.txt");
6         return namedFile;
7     }
8 }
```

```

9
10    @ContextConfiguration(
11        loader=AnnotationConfigApplicationContext.class,
12        classes=MyAppContext.class)
13    public class Xxx {
14        @Resource(name="namedFile")
15        private File defaultFile;
16    }

```

5.1.4 @Inject

The `@Inject` annotation matches by type, qualifier, or name (in this order). It is applicable to setter and field injection. With `@Inject`, the class reference variable's name and the bean name don't have to match.

To use the `@Inject` annotation, declare the `javax.inject` library as a Gradle or Maven dependency.

```

1  public class MyAppContext {
2      @Bean
3          // no bean name specified - method name is used
4          public File getSomeFile() {
5              File namedFile = new File("namedFile.txt");
6              return namedFile;
7          }
8      }
9
10     @ContextConfiguration(
11         loader=AnnotationConfigApplicationContext.class,
12         classes=MyAppContext.class)
13     public class Xxx {
14         @Inject
15         private File defaultFile;
16     }

```

5.1.5 @Value

We can use `@Value` for injecting property values into beans. It's compatible with constructor, setter, and field injection. E.g.,

```

1      Engine(@Value("8") int cylinderCount) {
2          this.cylinderCount = cylinderCount;

```

```
3 }
```

This is an alternative to making explicit use of Spring's Environment bean. E.g.

```
1 public DataSource dataSource(
2     @Value("${db.driver}") String driver,
3     ...
4     )
5 }
```

5.1.6 @DependsOn

We can use this annotation to make Spring initialize other beans before the annotated one. Usually, this behavior is automatic, based on the explicit dependencies between beans. We only need this annotation when the dependencies are implicit, for example, JDBC driver loading or static variable initialization. E.g.,

```
1 @Bean
2 @DependsOn("fuel")
3 Engine engine() {
4     return new Engine();
5 }
```

5.1.7 @Lazy

This annotation behaves differently depending on where exactly we place it.

- In an @Bean-annotated bean factory method, it is used to delay the method call (hence the bean creation)
- With an @Configuration class, all contained @Bean methods will be affected
- For all other @Component classes, they will be initialized lazily when so annotated.
- @Autowired constructors, setters, and fields will be loaded lazily (via proxy).

```
1 @Configuration
2 @Lazy
3 class VehicleFactoryConfig {
4
5     @Bean
6     @Lazy( false )
```

```
7         Engine engine() {
8             return new Engine();
9         }
10    }
```

5.1.8 @Scope

@Scope is used to define the scope of a @Component class or a @Bean definition. It can be either singleton, prototype, request, session, globalSession or some cust@Component.

5.2 Context Configuration Annotations

5.2.1 @Import

With @import, we can use specific @Configuration classes without component scanning.

```
1     @Import( VehiclePartSupplier.class )
2     class VehicleFactoryConfig {}
```

5.2.2 @ImportResource

We can import XML configurations with @ImportResource. We can specify the XML file locations with the locations argument, or with its alias, the value argument:

```
1     @Configuration
2     @ImportResource("classpath:/ annotations.xml")
3     class VehicleFactoryConfig {}
```

5.2.3 @PropertySource

With this annotation, we define property files for application settings.

```
1     @Configuration
2     @PropertySource("classpath:/ annotations.properties")
3     @PropertySource("classpath:/ vehicle-factory.properties")
4     class VehicleFactoryConfig {}
```

These properties can be used by Spring's Environment bean, in addition to environment variables and Java system properties.

Allowed prefixes are classpath:, file:, and http:.

5.3 Bean annotations

5.3.1 @Profile

Profiles are a way to group bean definitions, for example:

- dev, test, prod environment
- jdbc, jpa [implementations]

The @Profile annotation may be used in any of the following ways:

- At class level in @Configuration classes.
- At class level in classes annotated with @Component or annotated with any other annotation that in turn is annotated with @Component.
- On methods annotated with the @Bean annotation.

To define alternative beans with different profile conditions, use distinct Java method names pointing to the same bean name via the @Bean name attribute:

```
1      @Bean("dataSource")
2      @Profile("development")
3      public DataSource standaloneDataSource() {
4
5          @Bean("dataSource")
6          @Profile("production")
7          public DataSource jndiDataSource() throws Exception {
```

Spring uses two separate properties when determining which profiles are active, spring.profiles.active and spring.profiles.default:

- If spring.profiles.active is set, then its value determines which profiles are active.
- If spring.profiles.active isn't set, then Spring looks to spring.profiles.default.
- If neither spring.profiles.active nor spring.profiles.default is set, only those beans that aren't defined as being in a profile are created.

These properties can be set on the command line:

```
1      -Dspring.profiles.active=embedded.jpa
```

, programmatically:

```
1      System.setProperty("spring.profiles.active",
2                          "embedded.jpa");
```

, or via an annotation (@ActiveProfiles; integration tests only).

5.3.2 @ComponentScan

The `@ComponentScan` annotation is used together with `@Configuration`.

`@ComponentScan` can be used with and without arguments.

Without arguments, `@ComponentScan` tells Spring to scan the current package and all of its sub-packages.

With arguments, `@ComponentScan` tells which packages or classes to scan. E.g., specifying packages:

```
1  @Configuration  
2  @ComponentScan(basePackages =  
3      "com.baeldung.annotations")  
4  class VehicleFactoryConfig {}
```

Or else, specifying classes:

```
1  @Configuration  
2  @ComponentScan(basePackageClasses =  
3      VehicleFactoryConfig.class)  
4  class VehicleFactoryConfig {}
```

We can specify multiple package names, using spaces, commas, or semicolons as a separator.

```
1  @ComponentScan(basePackages =  
2      "com.baeldung.componentscan.springapp.animals;com.baeldung.componentscan.springapp.flowers")  
3  @ComponentScan(basePackages =  
4      "com.baeldung.componentscan.springapp.animals,com.baeldung.componentscan.springapp.flowers")  
5  @ComponentScan(basePackages =  
6      "com.baeldung.componentscan.springapp.animals  
7      com.baeldung.componentscan.springapp.flowers")
```

We could also apply a filter, choosing from a range of filter types. For example:

```
1  @ComponentScan(excludeFilters =  
2      @ComponentScan.Filter(type=FilterType.REGEX,  
3          pattern="com\\.baeldung\\.componentscan\\\\.springapp\\\\.flowers\\\\.*"))
```

Or:

```
1  @ComponentScan(excludeFilters =  
2      @ComponentScan.Filter(type =  
3          FilterType.ASSIGNABLE_TYPE, value = Rose.class))
```

5.3.3 @Component

@Component is a class-level annotation. During component scan, Spring automatically detects classes annotated with @Component.

```
1     @Component
2     class CarUtility {
3         // ...
4     }
```

@Repository, @Service, @Configuration, and @Controller are all meta-annotations of (i.e., themselves annotated with) @Component. E.g.,

```
1     @Component
2     public @interface Service {}
```

Spring also automatically picks them up during the component scanning process.

5.3.4 @Repository

```
1     @Repository
2     class VehicleRepository {
3         // ...
4     }
```

5.3.5 @Service

```
1     @Service
2     public class VehicleService {
3         // ...
4     }
```

5.3.6 @Controller

```
1     @Controller
2     public class VehicleController {
3         // ...
4     }
```

5.3.7 @Configuration

Configuration classes can contain bean definition methods annotated with @Bean.

```
1  @Configuration
2  class VehicleFactoryConfig {
3
4      @Bean
5      Engine engine() {
6          return new Engine();
7      }
8
9  }
```

5.4 Spring Boot Annotations

5.4.1 @SpringBootApplication

This is a combination of three annotations:

```
1  @Configuration
2  @EnableAutoConfiguration
3  @ComponentScan
```

5.4.2 @ConfigurationProperties

Helps keep configuration clean (see [7](#)).

This annotation has to be enabled via one of:

- @EnableConfigurationProperties on the application class

```
1  @SpringBootApplication
2  @EnableConfigurationProperties(
3      ConnectionSettings.class)
4  public class App {
5      // ...
6  }
```

- @ConfigurationPropertiesScan on the application class

```
1  @SpringBootApplication
2  @ConfigurationPropertiesScan
3  public class App {
```

- **@ConfigurationProperties** on dedicated bean
 - Will hold the externalized properties
 - Avoids repeating the prefix
 - Data-members automatically set from corresponding properties

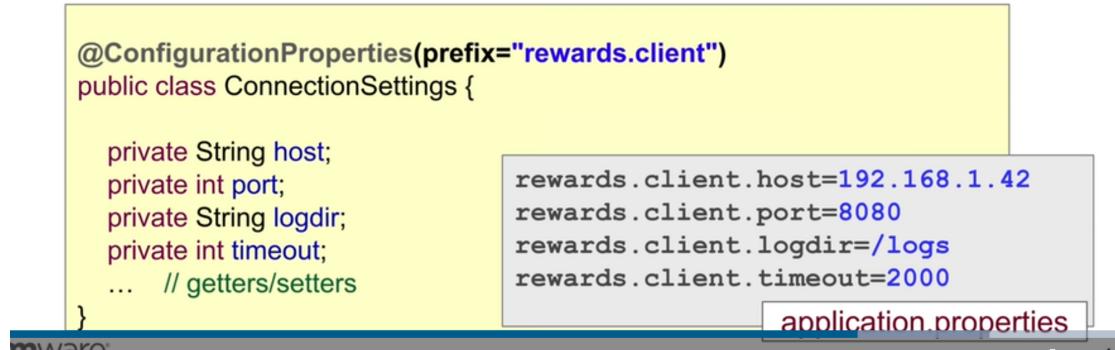


Figure 7:

```

4           // ...
5

```

- @Component on the configuration class

```

1   @Component
2   @ConfigurationProperties(prefix="...") 
3   public class ConnectionSettings {
4       // ...
5   }

```

5.4.3 @ConditionalOnX

Determine what auto configuration does. For example: @ConditionalOnBean, @ConditionalOnMissingBean, @ConditionalOnClass, @ConditionalOnMissingClass, @ConditionalOnProperty.

For example, @Profile is such a condition.

5.4.4 RestController

Includes @Controller and @ResponseBody (view subsystem is automatically turned off).

@RestController Convenience

- Convenient “composed” annotation
 - Incorporates `@Controller` and `@ResponseBody`
 - Methods assumed to return REST response-data

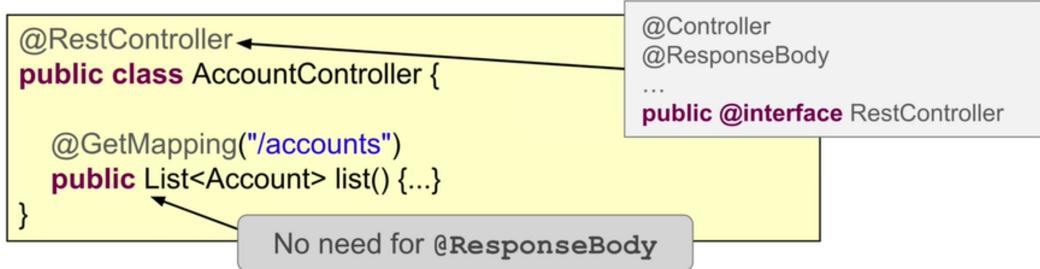


Figure 8: RestController conveniece annotation.

5.4.5 Request URI Decomposition: `@RequestParam`, `@PathVariable`

Do implicit type conversion of arguments.

```
1 // localhost:8080/account?userid=12345
2 @GetMapping("/account")
3 public List<Account> list(@RequestParam("userid") int
4     userid) {}
5
6 // localhost:8080/accounts/12345
7 @GetMapping("/accounts/{accountId}")
8 public Account find (@PathVariable("accountId") long id) {}
9
10 // if argument name is missing, will take from the mapping
11 // could also have
12
13 // localhost:8080/account?overdrawn=12345
14 @GetMapping("/account")
15 public List<Account> list(@RequestParam int overdrawn) {}
16
17 // localhost:8080/accounts/12345
18 @GetMapping("/accounts/{accountId}")
19 public Account find (@PathVariable long id) {}
20
21 // localhost:8080/accounts/12345?overdrawn=true
22 @GetMapping("/accounts/{accountId}")
23 public Account find (
```

```

23     @PathVariable long accountId,
24     @RequestParam boolean overdrawn
25 ) {}

```

5.4.6 @ResponseBody

Causes Java objects returned by the Controller to be processed by HttpMessageConverters in order to return information to the client in the form requested in the Accept header.

6 Aware Interfaces

Indicates that the bean is eligible to be notified by the Spring container through the callback methods. A typical use case for BeanNameAware could be acquiring the bean name for logging or wiring purposes. For the BeanFactoryAware it could be the ability to use a spring bean from legacy code. In most cases, we should avoid using any of the Aware interfaces, unless we need them. Implementing these interfaces will couple the code to the Spring framework.

6.1 BeanNameAware

Makes the object aware of the bean name defined in the container.

```

1 public class MyBeanName implements BeanNameAware {
2     @Override
3         public void setBeanName(String beanName) {
4             System.out.println(beanName);
5         }
6     }
7     @Configuration
8     public class Config {
9         @Bean(name = "myCustomBeanName")
10        public MyBeanName getMyBeanName() {
11            return new MyBeanName();
12        }
13    }
14    AnnotationConfigApplicationContext context
15    = new AnnotationConfigApplicationContext(Config.class);
16    MyBeanName myBeanName = context.getBean(MyBeanName.class);

```

6.2 BeanFactoryAware

Provides access to the BeanFactory which created the object.

```
1  public class MyBeanFactory implements BeanFactoryAware
2  {
3      private BeanFactory beanFactory;
4      @Override
5      public void setBeanFactory(BeanFactory
6          beanFactory) throws BeansException {
7          this.beanFactory = beanFactory;
8      }
9      public void getMyBeanName() {
10         MyBeanName myBeanName =
11             beanFactory.getBean(MyBeanName.class);
12         System.out.println(beanFactory.isSingleton("myCustomBeanName"));
13     }
14     MyBeanFactory myBeanFactory =
15         context.getBean(MyBeanFactory.class);
16     myBeanFactory.getMyBeanName();}
```

6.3 ApplicationContextAware

```
1  public class ApplicationContextAwareImpl implements
2  ApplicationContextAware {
3      @Override
4      public void
5          setApplicationContext(ApplicationContext
6              applicationContext) throws BeansException {
7          User user = (User)
8              applicationContext.getBean("user");
9          System.out.println("User Id: " +
10              user.getUserId() + " User Name :" +
11              user.getName());}}
```

7 Bean Naming

7.1 Default Bean Naming

7.1.1 Class-level ("Annotation-based configuration")

For an annotation used at the class level (@Component, @Service, @Controller), Spring uses the class name and converts the first letter to lowercase. Custom names may be configured in the annotation's value attribute.

The type is determined from the annotated class, typically resulting in the actual implementation class.

```
1      @Service  
2      public class LoggingService { // bean name =  
3          loggingService  
4      }
```

7.1.2 Method-level ("Java configuration")

When in a @Configuration class we use the @Bean annotation on a method, Spring uses the method name for the bean name.

```
1      @Configuration  
2      public class AuditConfiguration {  
3          @Bean  
4              public AuditService audit() {  
5                  return new AuditService();  
6              }  
7      }
```

7.2 Custom naming

```
1      @Component("myBean")  
2      public class MyCustomComponent {  
3      }
```

Custom names may be configured in @Bean's value attribute.

The type is determined from the method return type, typically resulting in an interface.

7.3 Naming Beans With @Bean and @Qualifier

7.3.1 @Bean With Value

The @Bean annotation is applied at the method level, and by default, Spring uses the method name as a bean name. We can override this using the @Bean annotation.

```
1  @Configuration
2  public class MyConfiguration {
3      @Bean("beanComponent")
4      public MyCustomComponent myComponent() {
5          return new MyCustomComponent();
6      }
7  }
```

7.3.2 @Qualifier With Value

We can also use the @Qualifier annotation to name the bean.

```
1  @Component
2  @Qualifier("cat")
3  public class Cat implements Animal {
4      @Override
5      public String name() {
6          return "Cat";
7      }
8  }
9  @Component
10 @Qualifier("dog")
11 public class Dog implements Animal {
12     @Override
13     public String name() {
14         return "Dog";
15     }
16 }
17 @Service
18 public class PetShow {
19     private final Animal dog;
20     private final Animal cat;
21
22     public PetShow (@Qualifier("dog")Animal dog,
23                     @Qualifier("cat")Animal cat) {
24         this.dog = dog;
25         this.cat = cat;
26     }
27 }
```

```

25      }
26      public Animal getDog() {
27          return dog;
28      }
29      public Animal getCat() {
30          return cat;
31      }
32  }

```

8 Spring Expression Language vs. Property Evaluation

Expressions in @Value annotations are of two types:

- Expressions starting with \$. Such expressions reference a property name in the application's environment. These expressions are evaluated by the PropertySourcePlaceholderConfigurer BeanFactoryPostProcessor prior to bean creation and can only be used in @Value annotations.
- Expressions starting with #. These expressions are parsed by a SpEL expression parser, and are evaluated by a SpEL expression instance.

In some cases, both can be used. For example, property values by default are Strings, but may be converted to primitives implicitly. So, both of these work:

```

1      @Value("${daily.limit}")
2      int limit;
3
4      @Value("#{environment['daily.limit']}")
5      int limit;

```

But if computations are to be performed, or object types are required, SpEL has to be used:

```

1      // NO
2      @Value("${daily.limit} * 2")
3
4      // instead, do
5      @Value("#{new Integer(environment['daily.limit']) * 2}")

```

To provide defaults, use a colon with property evaluation, and ?: in SpEL.

```

1      @Value("${daily.limit}: 1000")
2      int limit;
3
4      @Value("#${environment['daily.limit']} ?: 1000")
5      int limit;

```

In addition to application-defined beans, SpEL can make use of beans implicitly provided by Spring, namely environment, systemProperties, and systemEnvironment.

9 AOP in Spring

9.1 Core AOP concepts

9.1.1 Join Point

A point during the execution of a program, such as the execution of a method or the handling of an exception.

In Spring AOP, a join point always represents a method execution.

9.1.2 Point Cut

An expression that selects one or more join points.

Although Spring supports various AspectJ pointcut designators, the most commonly used one is execution.

For this designator, the syntax pattern is as follows:

```

1  execution(
2    modifiers-pattern?
3    ret-type-pattern
4    declaring-type-pattern.?name-pattern(param-pattern)
5    throws-pattern?
6  )

```

All parts except the returning type pattern (ret-type-pattern in the preceding snippet), the name pattern, and the parameters pattern are optional.

- The returning type pattern determines what the return type of the method must be in order for a join point to be matched. * is most frequently used as the returning type pattern. It matches any return type. A fully-qualified type name matches only when the method returns the given type.
- The name pattern matches the method name. You can use the * wildcard as all or part of a name pattern. If you specify a declaring type pattern, include a trailing . to join it to the name pattern component.

- The parameters pattern is slightly more complex: () matches a method that takes no parameters, whereas(..) matches any number (zero or more) of parameters. The (*) pattern matches a method that takes one parameter of any type. (*,String) matches a method that takes two parameters. The first can be of any type, while the second must be a String.

Examples:

```

1 // The execution of any public method:
2 execution(public * *(..))
3
4 // The execution of any method with a name that begins with
5 // set:
5 execution(* set*(..))
6
7 // The execution of any method defined by the AccountService
8 // interface:
8 execution(* com.xyz.service.AccountService.*(..))
9
10 // The execution of any method defined in the service package:
11 execution(* com.xyz.service.*.*(..))
12
13 //The execution of any method defined in the service package
14 // or one of its sub-packages:
14 execution(* com.xyz.service..*.*(..))
15
16 // There is one directory between rewards and restaurant.
17 execution(* rewards.*.restaurant.*.*(..))
18
19 // There are 0 or more directories between rewards and
20 // restaurant.
20 execution(* rewards..restaurant.*.*(..))
21
22 // There must be at least 1 directory before restaurant.
23 // omitting the star is not allowed
24 execution(* *..restaurant.*.*(..))
25
26 // Any join point (method execution only in Spring AOP) within
27 // the service package:
27 within(com.xyz.service.*)
28
29 // Any join point (method execution only in Spring AOP) within
30 // the service package or one of its sub-packages:
30 within(com.xyz.service..*)
31

```

```

32 // Any join point (method execution only in Spring AOP) where
   the proxy implements the AccountService interface:
33 this(com.xyz.service.AccountService)
34
35 // Any join point (method execution only in Spring AOP) where
   the target object implements the AccountService interface:
36 target(com.xyz.service.AccountService)
37
38 // Any join point (method execution only in Spring AOP) that
   takes a single parameter and where the argument passed at
   runtime is Serializable:
39 args(java.io.Serializable)
40
41 // Note that the pointcut given in this example is different
   from execution(* *(java.io.Serializable)). The args version
   matches if the argument passed at runtime is Serializable,
   and the execution version matches if the method signature
   declares a single parameter of type Serializable.
42
43 // Any join point (method execution only in Spring AOP) where
   the target object has a @Transactional annotation:
44 @target(org.springframework.transaction.annotation.Transactional)
45
46 // Any join point (method execution only in Spring AOP) where
   the declared type of the target object has an
   @Transactional annotation:
47 @within(org.springframework.transaction.annotation.Transactional)
48
49 // Any join point (method execution only in Spring AOP) where
   the executing method has an @Transactional annotation:
50 @annotation(org.springframework.transaction.annotation.Transactional)
51
52 // Any join point (method execution only in Spring AOP) which
   takes a single parameter, and where the runtime type of the
   argument passed has the @Classified annotation:
53 @args(com.xyz.security.Classified)
54
55 // Any join point (method execution only in Spring AOP) on a
   Spring bean named tradeService:
56 bean(tradeService)
57
58 // Any join point (method execution only in Spring AOP) on
   Spring beans having names that match the wildcard
   expression *Service:

```

9.1.3 Advice

Code to be executed at a particular join point. Types:

- Before-advice is executed before calling the target method.

```
1 @Before("execution(void set*(*))")
```

- After-advice is executed after the target method, whatever its outcome.

```
1 @Before("execution(void set*(*))")
```

- After-returning: executed after the target returns successfully. This advice will never execute if the target throws any exception. The return parameter also gives access to the returned object.

```
1 @AfterReturning(value="execution(*  
    service..*(..))", return="reward")  
2 public void audit(Join Point jp, Reward reward) {  
3     auditService.logEvent(jp.getSignature() + ":"  
4         + reward.toString());  
5 }
```

- After-throwing: executed after the target throws an exception. Also gives access to the exception.

```
1 // Repositories in any package  
2 @AfterThrowing(value="execution(*  
    *..Repository..*(..))", throwing="e")  
3 // also have to match the type of the exception  
4 public void report(JoinPoint jp,  
    DataAccessException e) {  
5     mailService.mailFailure(jp.getSignature(), e);  
6 }
```

While this advice cannot prevent an exception to be thrown, it can throw a more user-friendly exception instead:

- Use `@Around` annotation and a `ProceedingJoinPoint`
 - Inherits from `JoinPoint` and adds the `proceed()` method

```

@Around("execution(@example.Cacheable * rewards.service..*(..))")
public Object cache(ProceedingJoinPoint point) throws Throwable {
    Object value = cacheStore.get(CacheUtils.toKey(point));

    if (value != null) return value; // Value exists? If so just return it

    value = point.proceed(); // Proceed only if not already cached
    cacheStore.put(CacheUtils.toKey(point), value);
    return value;
}

```

Annotations and comments:

- `@Around("execution(@example.Cacheable * rewards.service..*(..))")`
- `public Object cache(ProceedingJoinPoint point) throws Throwable {`
- `Object value = cacheStore.get(CacheUtils.toKey(point));`
- `if (value != null) return value;` (with callout: "Value exists? If so just return it")
- `value = point.proceed();` (with callout: "Proceed only if not already cached")
- `cacheStore.put(CacheUtils.toKey(point), value);`
- `return value;`
- `}`
- `Cache values returned by cacheable services`

Figure 9: Around Advice

```

1  @AfterThrowing(value="execution(*
2      ... Repository.*(..)), throwing" e)
3  public void report(JoinPoint jp,
4      DataAccessException e) {
5      mailService.mailFailure(jp.getSignature(), e);
6      throw new RewardsException();
7  }

```

- Around: executed two times, before and after invocation of the target method. Must call `proceed()` to delegate to the target. See 9.

9.1.4 Aspect

The combination of point cut and advice. The `@aspect` annotation needs to be explicitly enabled by `@EnableAspectJConfiguration` set in the context (Config) class.

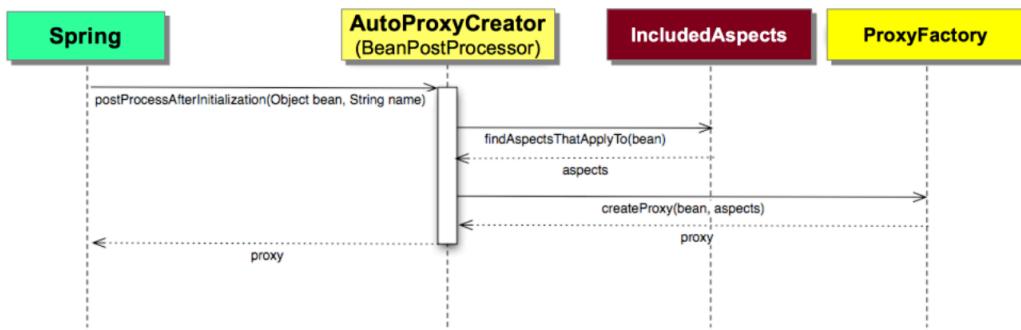
This will cause an extension of `AbstractAutoProxyCreator` to run, a `BeanPostProcessor` that wraps a bean with an AOP proxy. See 10.

An aspect can get context information by injecting the `JoinPoint` into the advice. See fig. 11.

```

1  public abstract class AbstractAutoProxyCreator extends
2      ProxyProcessorSupport
3  implements SmartInstantiationAwareBeanPostProcessor,
4      BeanFactoryAware {

```



This following shows the internal structure of a created proxy and what happens when it is invoked:

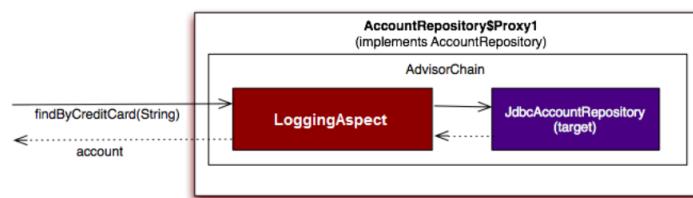


Figure 10: Proxy Creation.

Tracking Property Changes – With Context

```

@Aspect @Component
public class PropertyChangeTracker {
    private Logger logger = Logger.getLogger(getClass());

    @Before("execution(void set*(*))")
    public void trackChange(JoinPoint point) {
        String methodName = point.getSignature().getName();
        Object newValue = point.getArgs()[0];
        logger.info(methodName + " about to change to " +
                    newValue + " on " +
                    point.getTarget());
    }
}

```

JoinPoint parameter provides context about the intercepted point

toString() returns bean-name

Figure 11: Automatic JoinPoint injection

```

3 //...
4
5     @Override
6     public Object postProcessBeforeInstantiation (Class<?>
7         beanClass , String beanName) {
8         Object cacheKey = getCacheKey (beanClass , beanName);
9
10        if (!StringUtils .hasLength (beanName) ||
11            !this .targetSourcedBeans .contains (beanName)) {
12            if (this .advisedBeans .containsKey (cacheKey)) {
13                return null;
14            }
15            if (isInfrastructureClass (beanClass) ||
16                shouldSkip (beanClass , beanName)) {
17                this .advisedBeans .put (cacheKey ,
18                    Boolean .FALSE);
19                return null;
20            }
21        }
22
23        @Override
24        public Object postProcessAfterInitialization (@Nullable
25            Object bean , String beanName) {
26            if (bean != null) {
27                Object cacheKey = getCacheKey (bean .getClass () ,
28                    beanName);
29                if (this .earlyProxyReferences .remove (cacheKey)
30                    != bean) {
31                    return wrapIfNecessary (bean , beanName ,
32                        cacheKey);
33                }
34            }
35            return bean;
36        }
37    }

```

10 JPA

10.1 Repository Query Language

Example (see <https://docs.spring.io/spring-data/commons/reference/repositories/query-methods-details.html>):

```
1 interface PersonRepository extends Repository<Person , Long>
2 {
3     List<Person> findByEmailAddressAndLastname(EmailAddress
4         emailAddress , String lastname);
5     // Enables the distinct flag for the query
6     List<Person>
7         findDistinctPeopleByLastnameOrFirstname(String
8             lastname , String firstname);
9     List<Person>
10        findPeopleDistinctByLastnameOrFirstname(String
11            lastname , String firstname);
12
13    // Enabling ignoring case for an individual property
14    List<Person> findByLastnameIgnoreCase(String lastname);
15    // Enabling ignoring case for all suitable properties
16    List<Person>
17        findByLastnameAndFirstnameAllIgnoreCase(String
18            lastname , String firstname);
19
20    // Enabling static ORDER BY for a query
21    List<Person> findByLastnameOrderByFirstnameAsc(String
22        lastname);
23    List<Person> findByLastnameOrderByFirstnameDesc(String
24        lastname);
25 }
```

10.2 Reserved Method Names

Reserved methods like CrudRepository.findById (or just findById) are targeting the identifier property regardless of the actual property name used in the declared method.
Example:

```
1 class User {
2     //The identifier property (primary key).
3     @Id Long pk;
```

```

4
5      // A property named id , but not the identifier .
6      Long id ;
7  }
8
9  interface UserRepository extends Repository<User , Long> {
10
11     // Targets the pk property (the one marked with @Id
12     // which is considered to be the identifier) as it
13     // refers to a CrudRepository base repository method .
14     Optional<User> findById(Long id );
15
16     // Targets the pk property by name as it is a derived
17     // query .
18     Optional<User> findByPk(Long pk );
19

```

11 Paging, Iterating Large Results, Sorting and Limiting

Spring recognizes certain specific types like Pageable, Sort and Limit, to apply pagination, sorting and limiting to your queries dynamically. Example:

```

1   Page<User> findByLastname( String lastname , Pageable
2           pageable );
3
4   Slice<User> findByLastname( String lastname , Pageable
5           pageable );
6
7   List<User> findByLastname( String lastname , Sort sort );
8
9   List<User> findByLastname( String lastname , Sort sort ,
10          Limit limit );
11
12  List<User> findByLastname( String lastname , Pageable
13          pageable );

```

12 Repository Query Keywords

```
1  // General query method returning typically the repository
   type, a Collection or Streamable subtype or a result
   wrapper such as Page, GeoResults or any other
   store-specific result wrapper. Can be used as
   findBy..., findMyDomainTypeBy... or in combination with
   additional keywords.
2  find...By, read...By, get...By, query...By, search...By,
   stream...By
3
4  // Exists projection, returning typically a boolean result.
5  exists...By
6
7  // Count projection returning a numeric result.
8  count...By
9
10 // Delete query method returning either no result (void)
    or the delete count.
11 delete...By, remove...By
12
13 // Limit the query results to the first <number> of
   results. This keyword can occur in any place of the
   subject between find (and the other keywords) and by.
14 ...First<number>..., ...Top<number>...
15
16 // Use a distinct query to return only unique results.
   Consult the store-specific documentation whether that
   feature is supported. This keyword can occur in any
   place of the subject between find (and the other
   keywords) and by.
17 ...Distinct ...
```

13 Supported query method predicate keywords and modifiers

In addition to filter predicates, the following list of modifiers is supported:

- IgnoreCase, IgnoringCase
- AllIgnoreCase, AllIgnoringCase
- OrderBy... (e. g. OrderByFirstnameAscLastnameDesc).

Logical keyword	Keyword expressions
AND	And
OR	Or
AFTER	After, IsAfter
BEFORE	Before, IsBefore
CONTAINING	Containing, IsContaining, Contains
BETWEEN	Between, IsBetween
ENDING_WITH	EndingWith, IsEndingWith, EndsWith
EXISTS	Exists
FALSE	False, IsFalse
GREATER_THAN	GreaterThan, IsGreaterThan
GREATER_THAN_EQUALS	GreaterThanOrEqualTo, IsGreaterThanOrEqualTo
IN	In, IsIn
IS	Is, Equals, (or no keyword)
IS_EMPTY	IsEmpty, Empty
IS_NOT_EMPTY	IsNotEmpty, NotEmpty
IS_NOT_NULL	NotNull, IsNotNull
IS_NULL	Null,IsNull
LESS_THAN	LessThan, IsLessThan
LESS_THAN_EQUAL	LessThanOrEqualTo, IsLessThanOrEqualTo
LIKE	Like, IsLike
NEAR	Near, IsNear
NOT	Not, IsNotNOT_INNotIn, IsNotIn
NOT_LIKE	NotLike, IsNotLike
REGEX	Regex, MatchesRegex, Matches
STARTING_WITH	StartingWith, IsStartingWith, StartsWith
TRUE	True, IsTrue
WITHIN	Within, IsWithin

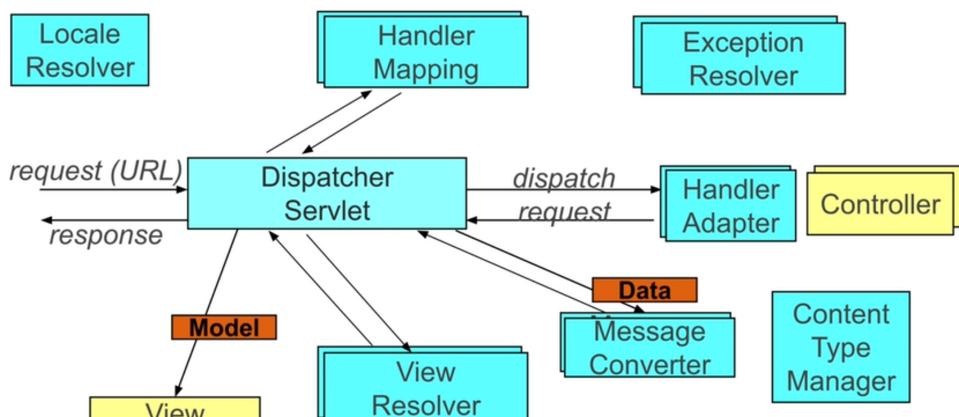
14 Supported query method predicate keywords and modifiers

15 Spring Boot Web

Architecture Overview:

Logical keyword	Keyword expressions
AND	And
OR	Or
AFTER	After, IsAfter
BEFORE	Before, IsBefore
CONTAINING	Containing, IsContaining, Contains
BETWEEN	Between, IsBetween
ENDING_WITH	EndingWith, IsEndingWith, EndsWith
EXISTS	Exists
FALSE	False, IsFalse
GREATER_THAN	GreaterThan, IsGreaterThan
GREATER_THAN_EQUALS	GreaterThanOrEqualTo, IsGreaterThanOrEqualTo
IN	In, IsIn
IS	Is, Equals, (or no keyword)
IS_EMPTY	IsEmpty, Empty
IS_NOT_EMPTY	IsNotEmpty, NotEmpty
IS_NOT_NULL	NotNull, IsNotNull
IS_NULL	Null,IsNull
LESS_THAN	LessThan, IsLessThan
LESS_THAN_EQUAL	LessThanOrEqualTo, IsLessThanOrEqualTo
LIKE	Like, IsLike
NEAR	Near, IsNear
NOT	Not, IsNot
NOT_IN	NotIn, IsNotIn
NOT_LIKE	NotLike, IsNotLike
REGEX	Regex, MatchesRegex, Matches
STARTING_WITH	StartingWith, IsStartingWith, StartsWith
TRUE	True, IsTrue
WITH	Within, IsWithin

At Startup Time, Spring Boot Creates Spring MVC Components



- Developers need to create only controllers and views (yellow-colored)

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Figure 12: Spring Boot Web Architecture Overview