基础篇：IoC

最简单的bean容器

> 代码分支：simple-bean-container

定义一个简单的bean容器BeanFactory，内部包含一个map用以保存bean，只有注册bean和获取bean两个方法

```
public class BeanFactory {
    private Map<String, Object> beanMap = new HashMap<>();

    public void registerBean(String name, Object bean) {
        beanMap.put(name, bean);
    }

    public Object getBean(String name) {
        return beanMap.get(name);
    }
}
```

测试：

```
public class SimpleBeanContainerTest {

    @Test
    public void testGetBean() throws Exception {
        BeanFactory beanFactory = new BeanFactory();
        beanFactory.registerBean("helloService", new HelloService());
        HelloService helloService = (HelloService)
beanFactory.getBean("helloService");
        assertThat(helloService).isNotNull();
        assertThat(helloService.sayHello()).isEqualTo("hello");
    }

    class HelloService {
        public String sayHello() {
            System.out.println("hello");
            return "hello";
        }
    }
}
```

BeanDefinition和BeanDefinitionRegistry

> 代码分支：bean-definition-and-bean-definition-registry

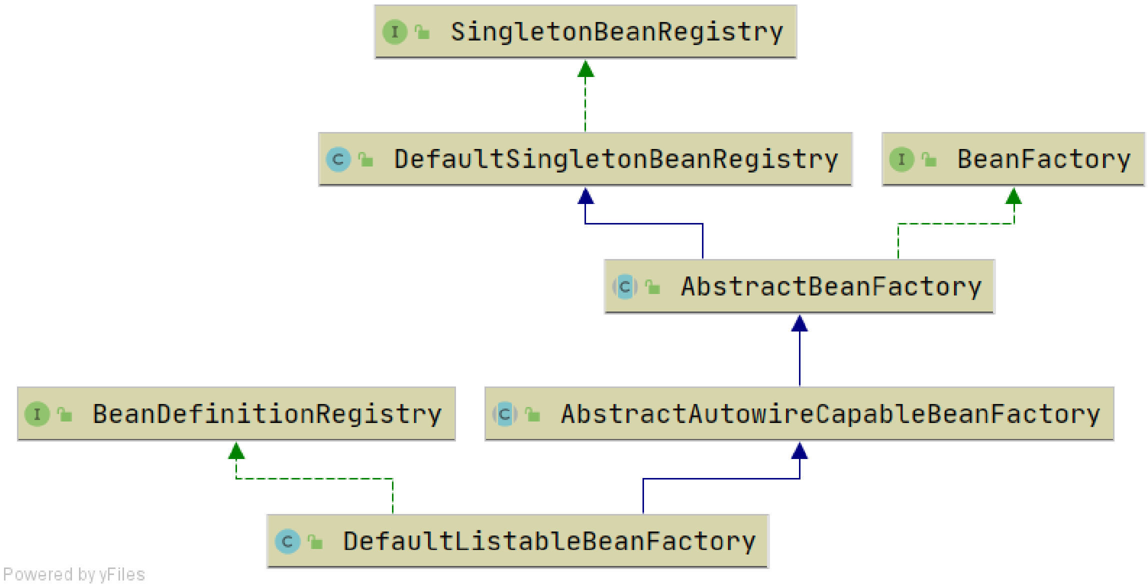
主要增加如下类：

- BeanDefinition，顾名思义，用于定义bean信息的类，包含bean的class类型、构造参数、属性值等信息，每个bean对应一个BeanDefinition的实例。简化BeanDefinition仅包含bean的class类

型。

- BeanDefinitionRegistry，BeanDefinition注册表接口，定义注册BeanDefinition的方法。
- SingletonBeanRegistry及其实现类DefaultSingletonBeanRegistry，定义添加和获取单例bean的方法。

bean容器作为BeanDefinitionRegistry和SingletonBeanRegistry的实现类，具备两者的能力。向bean容器中注册BeanDefinition后，使用bean时才会实例化。



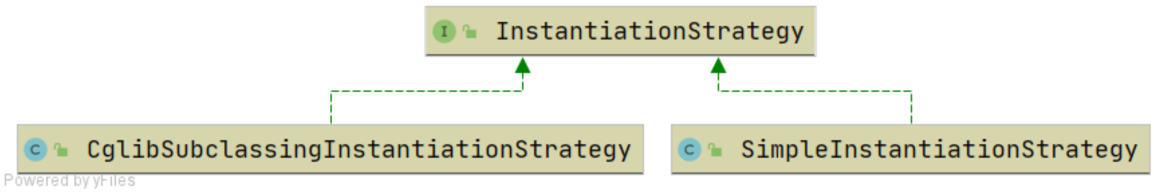
测试：

```
public class BeanDefinitionAndBeanDefinitionRegistryTest {

    @Test
    public void testBeanFactory() throws Exception {
        DefaultListableBeanFactory beanFactory = new
DefaultListableBeanFactory();
        BeanDefinition beanDefinition = new BeanDefinition(HelloService.class);
        beanFactory.registerBeanDefinition("helloService", beanDefinition);

        HelloService helloService = (HelloService)
beanFactory.getBean("helloService");
        helloService.sayHello();
    }
}

class HelloService {
    public String sayHello() {
        System.out.println("hello");
        return "hello";
    }
}
```

Bean实例化策略InstantiationStrategy

> 代码分支：instantiation-strategy

现在bean是在AbstractAutowireCapableBeanFactory.doCreateBean方法中用beanClass.newInstance()来实例化，仅适用于bean有无参构造函数的情况。


InstantiationStrategy
CglibSubclassingInstantiationStrategy
SimpleInstantiationStrategy
Powered by yFiles

针对bean的实例化，抽象出一个实例化策略的接口InstantiationStrategy，有两个实现类：

- SimpleInstantiationStrategy，使用bean的构造函数来实例化
- CglibSubclassingInstantiationStrategy，使用CGLIB动态生成子类

为bean填充属性

> 代码分支：populate-bean-with-property-values

在BeanDefinition中增加和bean属性对应的PropertyValues，实例化bean之后，为bean填充属性(AbstractAutowireCapableBeanFactory#applyPropertyValues)。

测试：

```
public class PopulateBeanWithPropertyValuesTest {

    @Test
    public void testPopulateBeanWithPropertyValues() throws Exception {
        DefaultListableBeanFactory beanFactory = new
DefaultListableBeanFactory();
        PropertyValues propertyValues = new PropertyValues();
        propertyValues.addPropertyValue(new PropertyValue("name", "derek"));
        propertyValues.addPropertyValue(new PropertyValue("age", 18));
        BeanDefinition beanDefinition = new BeanDefinition(Person.class,
propertyValues);
        beanFactory.registerBeanDefinition("person", beanDefinition);

        Person person = (Person) beanFactory.getBean("person");
        System.out.println(person);
        assertThat(person.getName()).isEqualTo("derek");
        assertThat(person.getAge()).isEqualTo(18);
    }
}
```

为bean注入bean

> 代码分支：populate-bean-with-bean

增加BeanReference类，包装一个bean对另一个bean的引用。实例化beanA后填充属性时，若PropertyValue#value为BeanReference，引用beanB，则先去实例化beanB。
由于不想增加代码的复杂度提高理解难度，暂时不支持循环依赖，后面会在高级篇中解决该问题。

```
protected void applyPropertyValues(String beanName, Object bean, BeanDefinition
beanDefinition) {
    try {
        for (PropertyValue propertyValue :
beanDefinition.getPropertyValues().getPropertyValues()) {
            String name = propertyValue.getName();
            Object value = propertyValue.getValue();
            if (value instanceof BeanReference) {
                // beanA依赖beanB，先实例化beanB
                BeanReference beanReference = (BeanReference) value;
                value = getBean(beanReference.getBeanName());
            }

            //通过反射设置属性
            BeanUtil.setFieldValue(bean, name, value);
        }
    } catch (Exception ex) {
        throw new BeansException("Error setting property values for bean: " +
beanName, ex);
    }
}
```

测试：

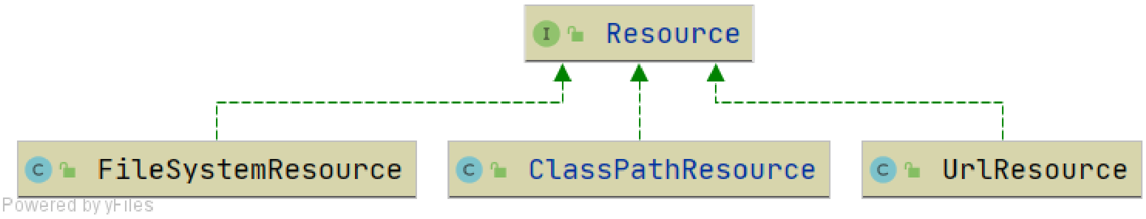
```
public class PopulateBeanWithPropertyValuesTest {

    /**
     * 为bean注入bean
     *
     * @throws Exception
     */
    @Test
    public void testPopulateBeanWithBean() throws Exception {
        DefaultListableBeanFactory beanFactory = new
DefaultListableBeanFactory();

        //注册Car实例
        PropertyValues propertyValuesForCar = new PropertyValues();
        propertyValuesForCar.addPropertyValue(new PropertyValue("brand",
"porsche"));
        BeanDefinition carBeanDefinition = new BeanDefinition(Car.class,
propertyValuesForCar);
        beanFactory.registerBeanDefinition("car", carBeanDefinition);

        //注册Person实例
        PropertyValues propertyValuesForPerson = new PropertyValues();
        propertyValuesForPerson.addPropertyValue(new PropertyValue("name",
"derek"));
        propertyValuesForPerson.addPropertyValue(new PropertyValue("age", 18));
        //Person实例依赖Car实例
        propertyValuesForPerson.addPropertyValue(new PropertyValue("car", new
BeanReference("car")));
        BeanDefinition beanDefinition = new BeanDefinition(Person.class,
propertyValuesForPerson);
        beanFactory.registerBeanDefinition("person", beanDefinition);

        Person person = (Person) beanFactory.getBean("person");
        System.out.println(person);
        assertThat(person.getName()).isEqualTo("derek");
        assertThat(person.getAge()).isEqualTo(18);
        Car car = person.getCar();
        assertThat(car).isNotNull();
```

```
            assertThat(car.getBrand()).isEqualTo("porsche");
        }
    }
```

资源和资源加载器

> 代码分支：resource-and-resource-loader

Resource是资源的抽象和访问接口，简单写了三个实现类



- FileSystemResource，文件系统资源的实现类
- ClassPathResource，classpath下资源的实现类
- UrlResource，对java.net.URL进行资源定位的实现类

ResourceLoader接口则是资源查找定位策略的抽象，DefaultResourceLoader是其默认实现类

测试：

```
public class ResourceAndResourceLoaderTest {

    @Test
    public void testResourceLoader() throws Exception {
        DefaultResourceLoader resourceLoader = new DefaultResourceLoader();

        //加载classpath下的资源
        Resource resource = resourceLoader.getResource("classpath:hello.txt");
        InputStream inputStream = resource.getInputStream();
        String content = IoUtil.readUtf8(inputStream);
        System.out.println(content);
        assertThat(content).isEqualTo("hello world");

        //加载文件系统资源
        resource = resourceLoader.getResource("src/test/resources/hello.txt");
        assertThat(resource instanceof FileSystemResource).isTrue();
        inputStream = resource.getInputStream();
        content = IoUtil.readUtf8(inputStream);
        System.out.println(content);
        assertThat(content).isEqualTo("hello world");

        //加载url资源
        resource = resourceLoader.getResource("https://www.baidu.com");
        assertThat(resource instanceof UrlResource).isTrue();
        inputStream = resource.getInputStream();
        content = IoUtil.readUtf8(inputStream);
        System.out.println(content);
    }
}
```

在xml文件中定义bean

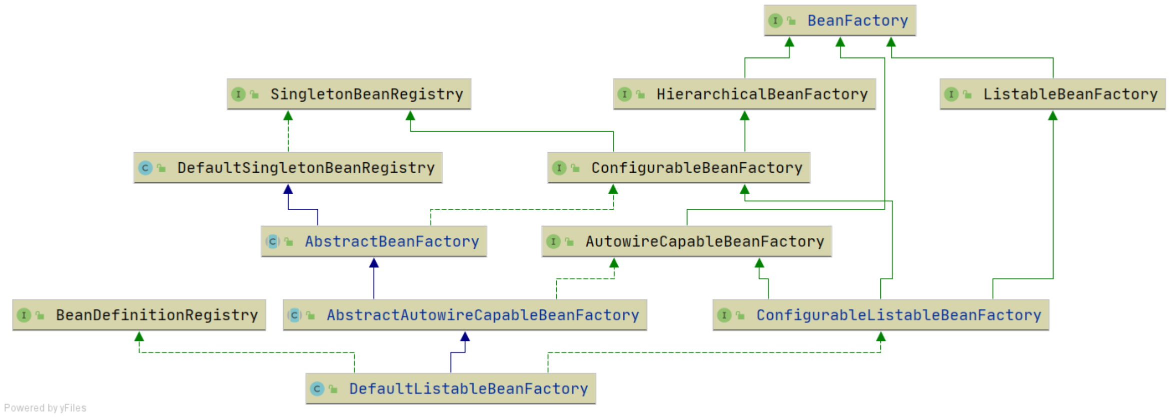
> 代码分支：xml-file-define-bean

有了资源加载器，就可以在xml格式配置文件中声明式地定义bean的信息，资源加载器读取xml文件，解析出bean的信息，然后往容器中注册BeanDefinition。

BeanDefinitionReader是读取bean定义信息的抽象接口，XmlBeanDefinitionReader是从xml文件中读取的实现类。BeanDefinitionReader需要有获取资源的能力，且读取bean定义信息后需要往容器中注册BeanDefinition，因此BeanDefinitionReader的抽象实现类AbstractBeanDefinitionReader拥有ResourceLoader和BeanDefinitionRegistry两个属性。

由于从xml文件中读取的内容是String类型，所以属性仅支持String类型和引用其他Bean。后面会讲到类型转换器，实现类型转换。

为了方便后面的讲解和功能实现，并且尽量保持和spring中BeanFactory的继承层次一致，对BeanFactory的继承层次稍微做了调整。



测试：
bean定义文件spring.xml

```
<?xml version="1.0" encoding="UTF-8"?>
<beans xmlns="http://www.springframework.org/schema/beans"
       xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
       xmlns:context="http://www.springframework.org/schema/context"
       xsi:schemaLocation="http://www.springframework.org/schema/beans
	         http://www.springframework.org/schema/beans/spring-beans.xsd
		 http://www.springframework.org/schema/context
		 http://www.springframework.org/schema/context/spring-context-4.0.xsd">

    <bean id="person" class="org.springframework.test.bean.Person">
        <property name="name" value="derek"/>
        <property name="car" ref="car"/>
    </bean>

    <bean id="car" class="org.springframework.test.bean.Car">
        <property name="brand" value="porsche"/>
    </bean>

</beans>
```

```
public class XmlFileDefineBeanTest {
    @Test
    public void testXmlFile() throws Exception {
        DefaultListableBeanFactory beanFactory = new
DefaultListableBeanFactory();
        XmlBeanDefinitionReader beanDefinitionReader = new
XmlBeanDefinitionReader(beanFactory);
        beanDefinitionReader.loadBeanDefinitions("classpath:spring.xml");

        Person person = (Person) beanFactory.getBean("person");
        System.out.println(person);
        assertThat(person.getName()).isEqualTo("derek");
        assertThat(person.getCar().getBrand()).isEqualTo("porsche");

        Car car = (Car) beanFactory.getBean("car");
        System.out.println(car);
        assertThat(car.getBrand()).isEqualTo("porsche");
    }
}
```

BeanFactoryPostProcessor和BeanPostProcessor

> 代码分支：bean-factory-post-processor-and-bean-post-processor

BeanFactoryPostProcessor和BeanPostProcessor是spring框架中具有重量级地位的两个接口，理解了这两个接口的作用，基本就理解spring的核心原理了。为了降低理解难度分两个小节实现。

BeanFactoryPostProcessor是spring提供的容器扩展机制，允许我们在bean实例化之前修改bean的定义信息即BeanDefinition的信息。其重要的实现类有PropertyPlaceholderConfigurer和CustomEditorConfigurer，PropertyPlaceholderConfigurer的作用是用properties文件的配置值替换xml文件中的占位符，CustomEditorConfigurer的作用是实现类型转换。BeanFactoryPostProcessor的实现比较简单，看单元测试BeanFactoryPostProcessorAndBeanPostProcessorTest#testBeanFactoryPostProcessor追下代码。

BeanPostProcessor也是spring提供的容器扩展机制，不同于BeanFactoryPostProcessor的是，BeanPostProcessor在bean实例化后修改bean或替换bean。BeanPostProcessor是后面实现AOP的关键。

BeanPostProcessor的两个方法分别在bean执行初始化方法（后面实现）之前和之后执行，理解其实现重点看单元测试BeanFactoryPostProcessorAndBeanPostProcessorTest#testBeanPostProcessor和AbstractAutowireCapableBeanFactory#initializeBean方法，有些地方做了微调，可不必关注。

```
public interface BeanPostProcessor {
    /**
     * 在bean执行初始化方法之前执行此方法
     */
    Object postProcessBeforeInitialization(Object bean, String beanName) throws
BeansException;

    /**
     * 在bean执行初始化方法之后执行此方法
     */
    Object postProcessAfterInitialization(Object bean, String beanName) throws
BeansException;
}
```

下一节将引入ApplicationContext，能自动识别BeanFactoryPostProcessor和BeanPostProcessor，就可以在xml文件中配置而不需要手动添加到BeanFactory了。

测试：

```
public class BeanFactoryProcessorAndBeanPostProcessorTest {

    @Test
    public void testBeanFactoryPostProcessor() throws Exception {
        DefaultListableBeanFactory beanFactory = new DefaultListableBeanFactory();
        XmlBeanDefinitionReader beanDefinitionReader = new XmlBeanDefinitionReader(beanFactory);
        beanDefinitionReader.loadBeanDefinitions("classpath:spring.xml");

        //在所有BeanDefintion加载完成后，但在bean实例化之前，修改BeanDefinition的属性值
        CustomBeanFactoryPostProcessor beanFactoryPostProcessor = new CustomBeanFactoryPostProcessor();
        beanFactoryPostProcessor.postProcessBeanFactory(beanFactory);

        Person person = (Person) beanFactory.getBean("person");
        System.out.println(person);
        //name属性在CustomBeanFactoryPostProcessor中被修改为ivy
        assertThat(person.getName()).isEqualTo("ivy");
    }

    @Test
    public void testBeanPostProcessor() throws Exception {
        DefaultListableBeanFactory beanFactory = new DefaultListableBeanFactory();
        XmlBeanDefinitionReader beanDefinitionReader = new XmlBeanDefinitionReader(beanFactory);
        beanDefinitionReader.loadBeanDefinitions("classpath:spring.xml");

        //添加bean实例化后的处理器
        CustomerBeanPostProcessor customerBeanPostProcessor = new CustomerBeanPostProcessor();
        beanFactory.addBeanPostProcessor(customerBeanPostProcessor);

        Car car = (Car) beanFactory.getBean("car");
        System.out.println(car);
        //brand属性在CustomerBeanPostProcessor中被修改为lamborghini
        assertThat(car.getBrand()).isEqualTo("lamborghini");
    }
}
```

应用上下文ApplicationContext

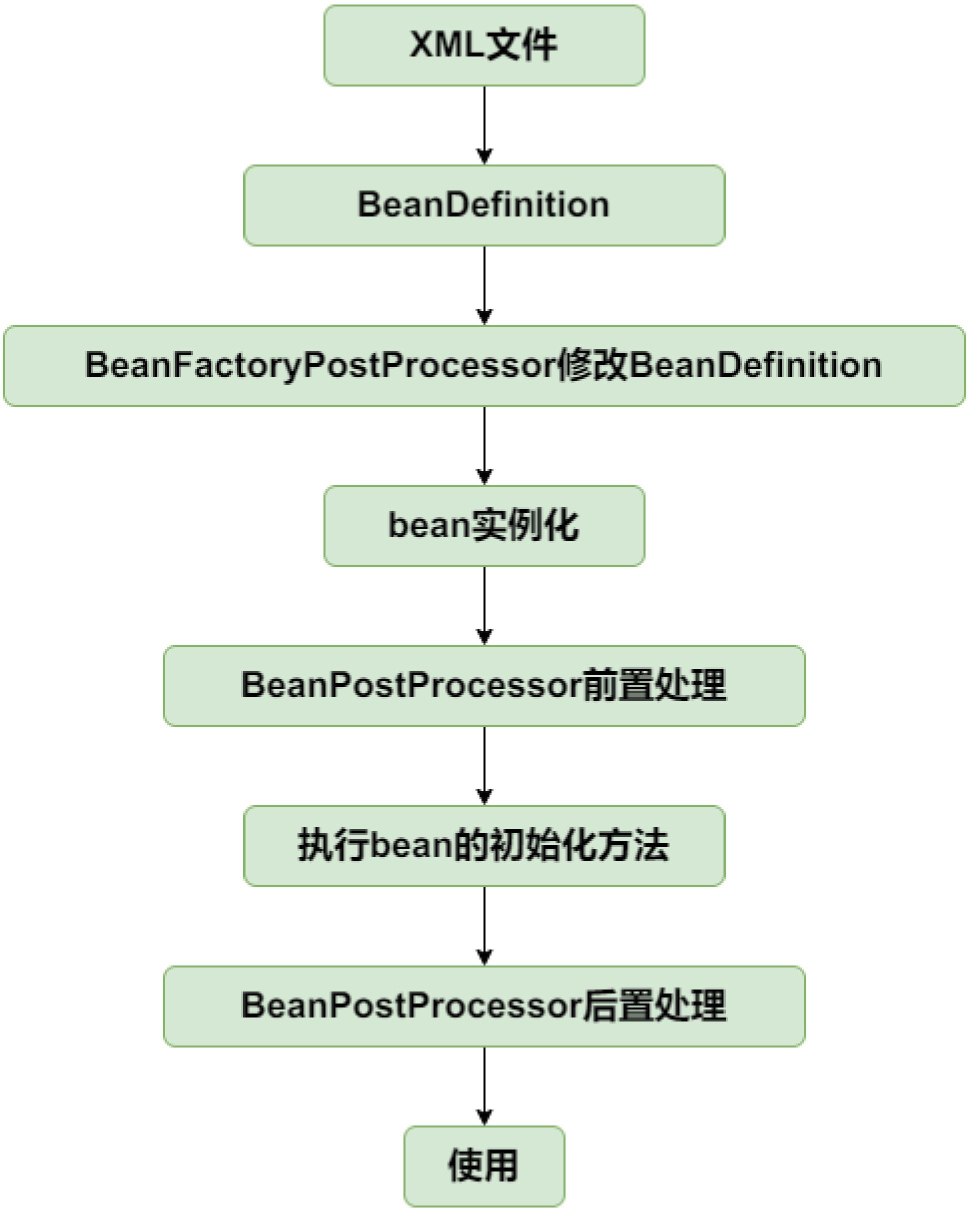
> 代码分支：application-context

应用上下文ApplicationContext是spring中较之于BeanFactory更为先进的IOC容器，ApplicationContext除了拥有BeanFactory的所有功能外，还支持特殊类型bean如上一节中的BeanFactoryPostProcessor和BeanPostProcessor的自动识别、资源加载、容器事件和监听器、国际化支持、单例bean自动初始化等。

BeanFactory是spring的基础设施，面向spring本身；而ApplicationContext面向spring的使用者，应用场合使用ApplicationContext。

具体实现查看AbstractApplicationContext#refresh方法即可。注意BeanFactoryPostProcessor和BeanPostProcessor的自动识别，这样就可以在xml文件中配置二者而不需要像上一节一样手动添加到容器中了。

从bean的角度看，目前生命周期如下：


XML文件
BeanDefinition
BeanFactoryPostProcessor修改BeanDefinition
bean实例化
BeanPostProcessor前置处理
执行bean的初始化方法
BeanPostProcessor后置处理
使用

测试：见ApplicationContextTest

bean的初始化和销毁方法

> 代码分支：init-and-destroy-method

在spring中，定义bean的初始化和销毁方法有三种方法：

- 在xml文件中制定init-method和destroy-method
- 继承自InitializingBean和DisposableBean
- 在方法上加注解PostConstruct和PreDestroy

第三种通过BeanPostProcessor实现，在扩展篇中实现，本节只实现前两种。

针对第一种在xml文件中指定初始化和销毁方法的方式，在BeanDefinition中增加属性initMethodName和destroyMethodName。

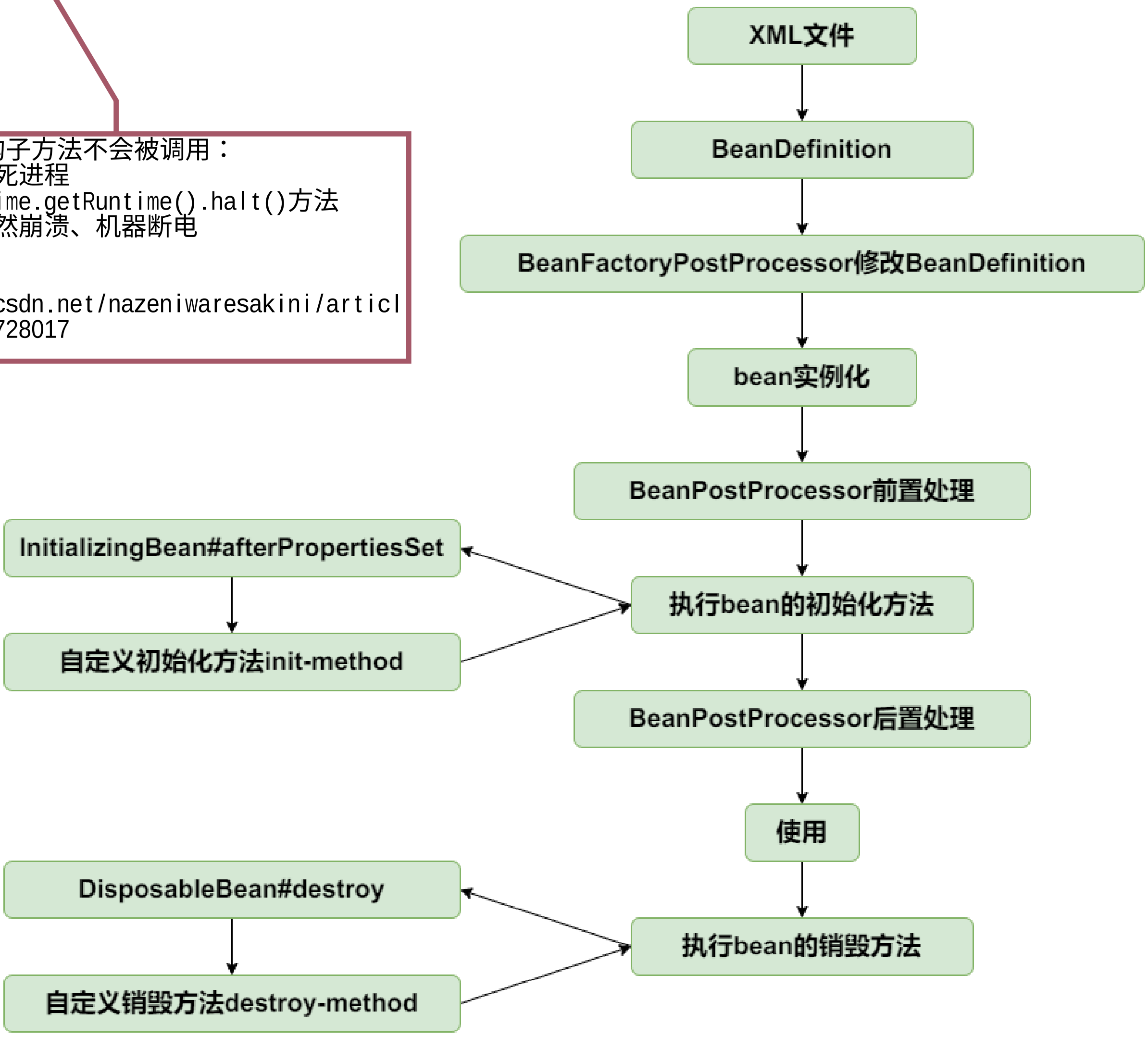
初始化方法在AbstractAutowireCapableBeanFactory#invokeInitMethods执行。DefaultSingletonBeanRegistry中增加属性disposableBeans保存拥有销毁方法的bean，拥有销毁方法的bean在AbstractAutowireCapableBeanFactory#registerDisposableBeanIfNecessary中注册到disposableBeans中。

为了确保销毁方法在虚拟机关闭之前执行，向虚拟机中注册一个钩子方法，查看AbstractApplicationContext#registerShutdownHook（非web应用需要手动调用该方法）。当然也可以手动调用ApplicationContext#close方法关闭容器。

在以下场景下钩子方法不会被调用：
1. kill -9 杀死进程
2. 执行了Runtime.getRuntime().halt()方法
3. 操作系统突然崩溃、机器断电

参考：
https://blog.csdn.net/nazeniwaresakini/article/details/108728017

到此为止，bean的生命周期如下：


XML文件
BeanDefinition
BeanFactoryPostProcessor修改BeanDefinition
bean实例化
BeanPostProcessor前置处理
InitializingBean#afterPropertiesSet
执行bean的初始化方法
自定义初始化方法init-method
BeanPostProcessor后置处理
使用
DisposableBean#destroy
执行bean的销毁方法
自定义销毁方法destroy-method

测试：
init-and-destroy-method.xml

```
<?xml version="1.0" encoding="UTF-8"?>
<beans xmlns="http://www.springframework.org/schema/beans"
       xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
       xmlns:context="http://www.springframework.org/schema/context"
       xsi:schemaLocation="http://www.springframework.org/schema/beans
             http://www.springframework.org/schema/beans/spring-beans.xsd
         http://www.springframework.org/schema/context
         http://www.springframework.org/schema/context/spring-context-4.0.xsd">
```

```xml
    <bean id="person" class="org.springframework.test.bean.Person" init-method="customInitMethod" destroy-method="customDestroyMethod">
        <property name="name" value="derek"/>
        <property name="car" ref="car"/>
    </bean>

    <bean id="car" class="org.springframework.test.bean.Car">
        <property name="brand" value="porsche"/>
    </bean>

</beans>
```

```java
public class Person implements InitializingBean, DisposableBean {

    private String name;

    private int age;

    private Car car;

    public void customInitMethod() {
        System.out.println("I was born in the method named customInitMethod");
    }

    public void customDestroyMethod() {
        System.out.println("I died in the method named customDestroyMethod");
    }

    @Override
    public void afterPropertiesSet() throws Exception {
        System.out.println("I was born in the method named afterPropertiesSet");
    }

    @Override
    public void destroy() throws Exception {
        System.out.println("I died in the method named destroy");
    }

    //setter and getter
}
```

```java
public class InitAndDestoryMethodTest {

    @Test
    public void testInitAndDestroyMethod() throws Exception {
        ClassPathXmlApplicationContext applicationContext = new ClassPathXmlApplicationContext("classpath:init-and-destroy-method.xml");
        applicationContext.registerShutdownHook();  //或者手动关闭 applicationContext.close();
    }
}
```

Aware接口

> 代码分支：aware-interface

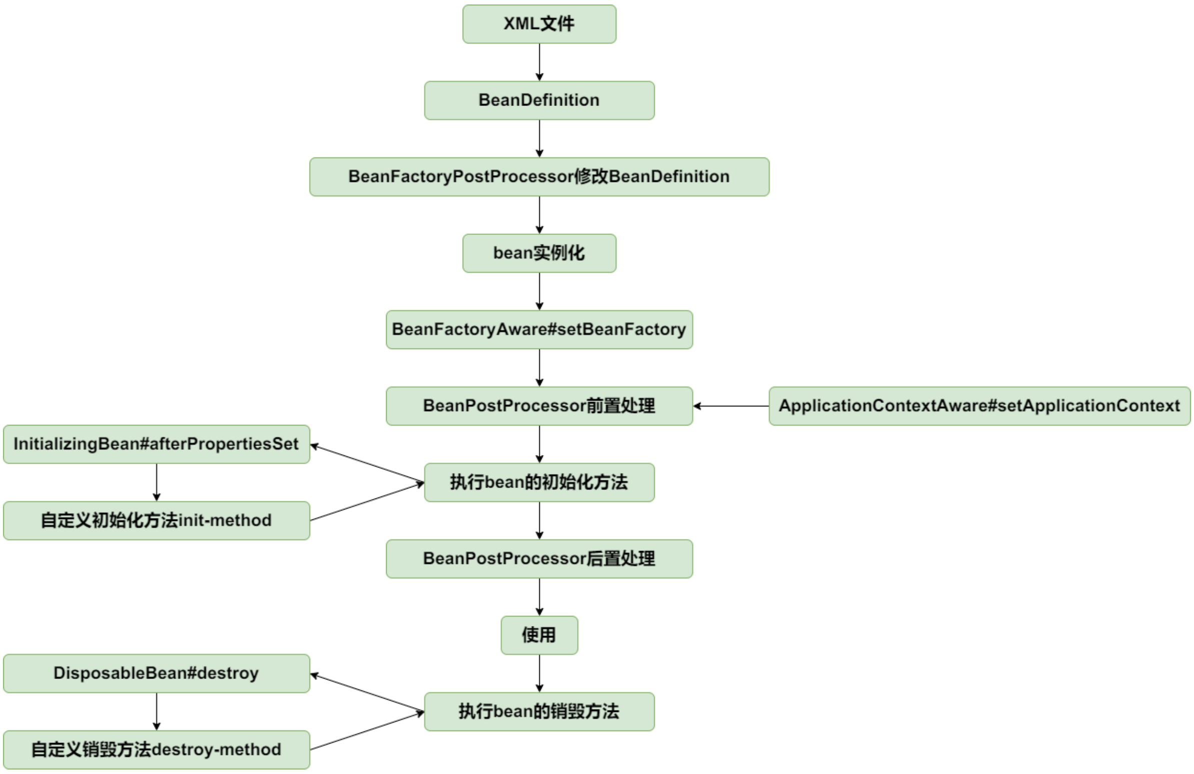
Aware是感知、意识的意思，Aware接口是标记性接口，其实现子类能感知容器相关的对象。常用的Aware接口有BeanFactoryAware和ApplicationContextAware，分别能让其实现者感知所属的BeanFactory和ApplicationContext。

让实现BeanFactoryAware接口的类能感知所属的BeanFactory，实现比较简单，查看AbstractAutowireCapableBeanFactory#initializeBean前三行。

实现ApplicationContextAware的接口感知ApplicationContext，是通过BeanPostProcessor。由bean的生命周期可知，bean实例化后会经过BeanPostProcessor的前置处理和后置处理。定义一个BeanPostProcessor的实现类ApplicationContextAwareProcessor，在AbstractApplicationContext#refresh方法中加入到BeanFactory中，在前置处理中为bean设置所属的ApplicationContext。

改用dom4j解析xml文件。

至止，bean的生命周期如下：


XML文件
BeanDefinition
BeanFactoryPostProcessor修改BeanDefinition
bean实例化
BeanFactoryAware#setBeanFactory
BeanPostProcessor前置处理
ApplicationContextAware#setApplicationContext
InitializingBean#afterPropertiesSet
执行bean的初始化方法
自定义初始化方法init-method
BeanPostProcessor后置处理
使用
DisposableBean#destroy
执行bean的销毁方法
自定义销毁方法destroy-method

测试：
spring.xml

```
<?xml version="1.0" encoding="UTF-8"?>
<beans xmlns="http://www.springframework.org/schema/beans"
       xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
       xmlns:context="http://www.springframework.org/schema/context"
       xsi:schemaLocation="http://www.springframework.org/schema/beans
             http://www.springframework.org/schema/beans/spring-beans.xsd
         http://www.springframework.org/schema/context
         http://www.springframework.org/schema/context/spring-context-4.0.xsd">

    <bean id="helloService"
class="org.springframework.test.service.HelloService"/>

</beans>
```

```
public class HelloService implements ApplicationContextAware, BeanFactoryAware {

    private ApplicationContext applicationContext;

    private BeanFactory beanFactory;

    @Override
    public void setBeanFactory(BeanFactory beanFactory) throws BeansException {
        this.beanFactory = beanFactory;
    }

    @Override
    public void setApplicationContext(ApplicationContext applicationContext)
throws BeansException {
        this.applicationContext = applicationContext;
    }

    public ApplicationContext getApplicationContext() {
        return applicationContext;
    }

    public BeanFactory getBeanFactory() {
        return beanFactory;
    }
}
```

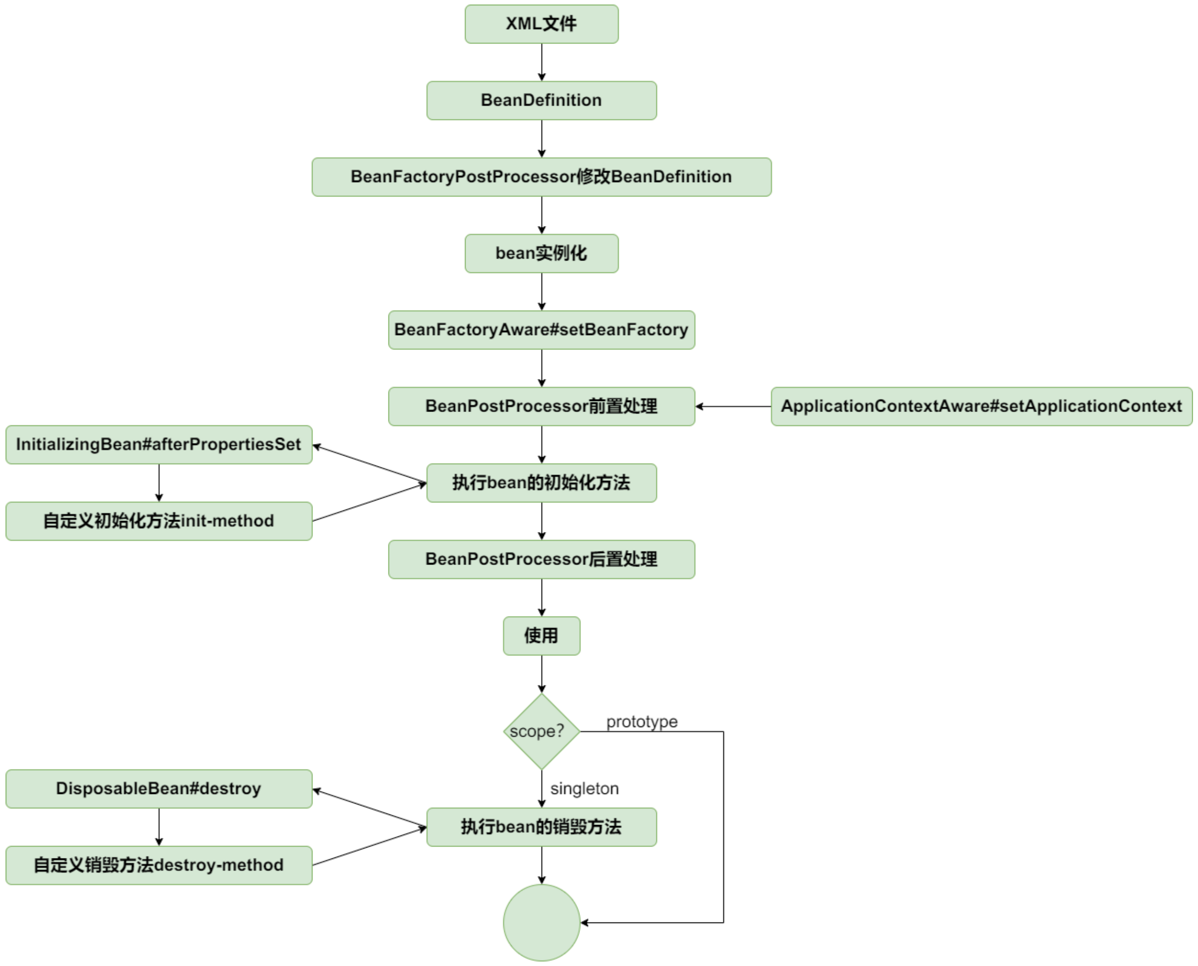
```
public class AwareInterfaceTest {

    @Test
    public void test() throws Exception {
        ClassPathXmlApplicationContext applicationContext = new
ClassPathXmlApplicationContext("classpath:spring.xml");
        HelloService helloService = applicationContext.getBean("helloService",
HelloService.class);
        assertThat(helloService.getApplicationContext()).isNotNull();
        assertThat(helloService.getBeanFactory()).isNotNull();
    }
}
```

bean作用域，增加prototype的支持

> 代码分支：prototype-bean

每次向容器获取prototype作用域bean时，容器都会创建一个新的实例。在BeanDefinition中增加描述bean的作用域的字段scope，创建prototype作用域bean时（AbstractAutowireCapableBeanFactory#doCreateBean），不往singletonObjects中增加该bean。prototype作用域bean不执行销毁方法，查看AbstractAutowireCapableBeanFactory#registerDisposableBeanIfNecessary方法。

至止，bean的生命周期如下：


XML文件
BeanDefinition
BeanFactoryPostProcessor修改BeanDefinition
bean实例化
BeanFactoryAware#setBeanFactory
BeanPostProcessor前置处理
ApplicationContextAware#setApplicationContext
InitializingBean#afterPropertiesSet
执行bean的初始化方法
自定义初始化方法init-method
BeanPostProcessor后置处理
使用
scope?
prototype
singleton
DisposableBean#destroy
执行bean的销毁方法
自定义销毁方法destroy-method

测试：

prototype-bean.xml

```xml
<?xml version="1.0" encoding="UTF-8"?>
<beans xmlns="http://www.springframework.org/schema/beans"
       xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
       xmlns:context="http://www.springframework.org/schema/context"
       xsi:schemaLocation="http://www.springframework.org/schema/beans
             http://www.springframework.org/schema/beans/spring-beans.xsd
         http://www.springframework.org/schema/context
         http://www.springframework.org/schema/context/spring-context-4.0.xsd">

    <bean id="car" class="org.springframework.test.bean.Car" scope="prototype">
        <property name="brand" value="porsche"/>
    </bean>

</beans>
```

```
public class PrototypeBeanTest {

    @Test
    public void testPrototype() throws Exception {
        ClassPathXmlApplicationContext applicationContext = new
ClassPathXmlApplicationContext("classpath:prototype-bean.xml");

        Car car1 = applicationContext.getBean("car", Car.class);
        Car car2 = applicationContext.getBean("car", Car.class);
        assertThat(car1 != car2).isTrue();
    }
}
```

FactoryBean

> 代码分支：factory-bean

FactoryBean是一种特殊的bean，当向容器获取该bean时，容器不是返回其本身，而是返回其FactoryBean#getObject方法的返回值，可通过编码方式定义复杂的bean。

实现逻辑比较简单，当容器发现bean为FactoryBean类型时，调用其getObject方法返回最终bean。当FactoryBean#isSingleton==true，将最终bean放进缓存中，下次从缓存中获取。改动点见AbstractBeanFactory#getBean。

测试：
factory-bean.xml

```
<?xml version="1.0" encoding="UTF-8"?>
<beans xmlns="http://www.springframework.org/schema/beans"
       xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
       xmlns:context="http://www.springframework.org/schema/context"
       xsi:schemaLocation="http://www.springframework.org/schema/beans
             http://www.springframework.org/schema/beans/spring-beans.xsd
         http://www.springframework.org/schema/context
         http://www.springframework.org/schema/context/spring-context-4.0.xsd">

    <bean id="car" class="org.springframework.test.common.CarFactoryBean">
        <property name="brand" value="porsche"/>
    </bean>

</beans>
```

```
public class CarFactoryBean implements FactoryBean<Car> {

    private String brand;

    @Override
    public Car getObject() throws Exception {
        Car car = new Car();
        car.setBrand(brand);
        return car;
    }

    @Override
    public boolean isSingleton() {
        return true;
    }

    public void setBrand(String brand) {
        this.brand = brand;
    }
}
```

```
public class FactoryBeanTest {

    @Test
    public void testFactoryBean() throws Exception {
        ClassPathXmlApplicationContext applicationContext = new
ClassPathXmlApplicationContext("classpath:factory-bean.xml");

        Car car = applicationContext.getBean("car", Car.class);
        applicationContext.getBean("car");
        assertThat(car.getBrand()).isEqualTo("porsche");
    }
}
```

容器事件和事件监听器

这么一看，还挺简单的嘛

> 代码分支：event-and-event-listener

ApplicationContext容器提供了完善的事件发布和事件监听功能。

ApplicationEventMulticaster接口是注册监听器和发布事件的抽象接口，AbstractApplicationContext包含其实现类实例作为其属性，使得ApplicationContext容器具有注册监听器和发布事件的能力。在AbstractApplicationContext#refresh方法中，会实例化ApplicationEventMulticaster、注册监听器并发布容器刷新事件ContextRefreshedEvent；在AbstractApplicationContext#doClose方法中，发布容器关闭事件ContextClosedEvent。

测试：
event-and-event-listener.xml

```
<?xml version="1.0" encoding="UTF-8"?>
<beans xmlns="http://www.springframework.org/schema/beans"
       xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
       xmlns:context="http://www.springframework.org/schema/context"
       xsi:schemaLocation="http://www.springframework.org/schema/beans
             http://www.springframework.org/schema/beans/spring-beans.xsd
         http://www.springframework.org/schema/context
         http://www.springframework.org/schema/context/spring-context-4.0.xsd">

    <bean
class="org.springframework.test.common.event.ContextRefreshedEventListener"/>

    <bean class="org.springframework.test.common.event.CustomEventListener"/>

    <bean
class="org.springframework.test.common.event.ContextClosedEventListener"/>
</beans>
```

```
public class EventAndEventListenerTest {

    @Test
    public void testEventListener() throws Exception {
        ClassPathXmlApplicationContext applicationContext = new
ClassPathXmlApplicationContext("classpath:event-and-event-listener.xml");
        applicationContext.publishEvent(new CustomEvent(applicationContext));

        applicationContext.registerShutdownHook();//或者
applicationContext.close()主动关闭容器;
    }
}
```

观察输出：

```
org.springframework.test.common.event.ContextRefreshedEventListener
org.springframework.test.common.event.CustomEventListener
org.springframework.test.common.event.ContextClosedEventListener
```

基础篇：AOP

切点表达式

> 代码分支：pointcut-expression

Joinpoint，织入点，指需要执行代理操作的某个类的某个方法(仅支持方法级别的JoinPoint)；Pointcut是JoinPoint的表述方式，能捕获JoinPoint。

最常用的切点表达式是AspectJ的切点表达式。需要匹配类，定义ClassFilter接口；匹配方法，定义MethodMatcher接口。PointCut需要同时匹配类和方法，包含ClassFilter和MethodMatcher，AspectJExpressionPointcut是支持AspectJ切点表达式的PointCut实现，简单实现仅支持execution函数。

测试：

```
public class HelloService {
    public String sayHello() {
        System.out.println("hello");
        return "hello";
    }
}
```

```
public class PointcutExpressionTest {

    @Test
    public void testPointcutExpression() throws Exception {
        AspectJExpressionPointcut pointcut = new
AspectJExpressionPointcut("execution(*
org.springframework.test.service.HelloService.*(..))");
        Class<HelloService> clazz = HelloService.class;
        Method method = clazz.getDeclaredMethod("sayHello");

        assertThat(pointcut.matches(clazz)).isTrue();
        assertThat(pointcut.matches(method, clazz)).isTrue();
    }
}
```

基于JDK的动态代理

> 代码分支：jdk-dynamic-proxy

AopProxy是获取代理对象的抽象接口，JdkDynamicAopProxy的基于JDK动态代理的具体实现。TargetSource，被代理对象的封装。MethodInterceptor，方法拦截器，是AOP Alliance的"公民"，顾名思义，可以拦截方法，可在被代理执行的方法前后增加代理行为。

测试;

```
public class DynamicProxyTest {

    @Test
    public void testJdkDynamicProxy() throws Exception {
        WorldService worldService = new WorldServiceImpl();

        AdvisedSupport advisedSupport = new AdvisedSupport();
        TargetSource targetSource = new TargetSource(worldService);
        WorldServiceInterceptor methodInterceptor = new
WorldServiceInterceptor();
        MethodMatcher methodMatcher = new AspectJExpressionPointcut("execution(*
org.springframework.test.service.WorldService.explode(..))").getMethodMatcher();
        advisedSupport.setTargetSource(targetSource);
        advisedSupport.setMethodInterceptor(methodInterceptor);
        advisedSupport.setMethodMatcher(methodMatcher);

        WorldService proxy = (WorldService) new
JdkDynamicAopProxy(advisedSupport).getProxy();
        proxy.explode();
    }
}
```

基于CGLIB的动态代理

> 代码分支：cglib-dynamic-proxy

基于CGLIB的动态代理实现逻辑也比较简单，查看CglibAopProxy。与基于JDK的动态代理在运行期间为接口生成对象的代理对象不同，基于CGLIB的动态代理能在运行期间动态构建字节码的class文件，为类生成子类，因此被代理类不需要继承自任何接口。

测试：

```
public class DynamicProxyTest {

    private AdvisedSupport advisedSupport;

    @Before
    public void setup() {
        WorldService worldService = new WorldServiceImpl();

        advisedSupport = new AdvisedSupport();
        TargetSource targetSource = new TargetSource(worldService);
        WorldServiceInterceptor methodInterceptor = new WorldServiceInterceptor();
        MethodMatcher methodMatcher = new AspectJExpressionPointcut("execution(* org.springframework.test.service.WorldService.explode(..))").getMethodMatcher();
        advisedSupport.setTargetSource(targetSource);
        advisedSupport.setMethodInterceptor(methodInterceptor);
        advisedSupport.setMethodMatcher(methodMatcher);
    }

    @Test
    public void testCglibDynamicProxy() throws Exception {
        WorldService proxy = (WorldService) new CglibAopProxy(advisedSupport).getProxy();
        proxy.explode();
    }
}
```

AOP代理工厂

> 代码分支：proxy-factory

增加AOP代理工厂ProxyFactory，由AdvisedSupport#proxyTargetClass属性决定使用JDK动态代理还是CGLIB动态代理。

测试：

```
public class DynamicProxyTest {

    private AdvisedSupport advisedSupport;

    @Before
    public void setup() {
        WorldService worldService = new WorldServiceImpl();

        advisedSupport = new AdvisedSupport();
        TargetSource targetSource = new TargetSource(worldService);
        WorldServiceInterceptor methodInterceptor = new WorldServiceInterceptor();
        MethodMatcher methodMatcher = new AspectJExpressionPointcut("execution(* org.springframework.test.service.WorldService.explode(..))").getMethodMatcher();
        advisedSupport.setTargetSource(targetSource);
        advisedSupport.setMethodInterceptor(methodInterceptor);
        advisedSupport.setMethodMatcher(methodMatcher);
    }

    @Test
    public void testProxyFactory() throws Exception {
        // 使用JDK动态代理
        advisedSupport.setProxyTargetClass(false);
        WorldService proxy = (WorldService) new
ProxyFactory(advisedSupport).getProxy();
        proxy.explode();

        // 使用CGLIB动态代理
        advisedSupport.setProxyTargetClass(true);
        proxy = (WorldService) new ProxyFactory(advisedSupport).getProxy();
        proxy.explode();
    }
}
```

几种常用的Advice：BeforeAdvice/AfterAdvice/AfterReturningAdvice/ThrowsAdvice...

> 代码分支：common-advice

Spring将AOP联盟中的Advice细化出各种类型的Advice，常用的有BeforeAdvice/AfterAdvice/AfterReturningAdvice/ThrowsAdvice，我们可以通过扩展MethodInterceptor来实现。

只简单实现BeforeAdvice，有兴趣的同学可以帮忙实现另外几种Advice。定义MethodBeforeAdviceInterceptor拦截器，在执行被代理方法之前，先执行BeforeAdvice的方法。

- ☑ BeforeAdvice
- □ AfterAdvice
- □ AfterReturningAdvice
- □ ThrowsAdvice

测试：

```
public class WorldServiceBeforeAdvice implements MethodBeforeAdvice {

    @Override
    public void before(Method method, Object[] args, Object target) throws
Throwable {
        System.out.println("BeforeAdvice: do something before the earth
explodes");
    }
}
```

```
public class DynamicProxyTest {

    private AdvisedSupport advisedSupport;

    @Before
    public void setup() {
        WorldService worldService = new WorldServiceImpl();

        advisedSupport = new AdvisedSupport();
        TargetSource targetSource = new TargetSource(worldService);
        MethodMatcher methodMatcher = new AspectJExpressionPointcut("execution(* org.springframework.test.service.WorldService.explode(..))").getMethodMatcher();
        advisedSupport.setTargetSource(targetSource);
        advisedSupport.setMethodMatcher(methodMatcher);
    }

    @Test
    public void testBeforeAdvice() throws Exception {
        //设置BeforeAdvice
        WorldServiceBeforeAdvice beforeAdvice = new WorldServiceBeforeAdvice();
        MethodBeforeAdviceInterceptor methodInterceptor = new MethodBeforeAdviceInterceptor(beforeAdvice);
        advisedSupport.setMethodInterceptor(methodInterceptor);

        WorldService proxy = (WorldService) new ProxyFactory(advisedSupport).getProxy();
        proxy.explode();
    }
}
```

PointcutAdvisor：Pointcut和Advice的组合

> 代码分支：pointcut-advisor

Advisor是包含一个Pointcut和一个Advice的组合，Pointcut用于捕获JoinPoint，Advice决定在JoinPoint执行某种操作。实现了一个支持aspectj表达式的AspectJExpressionPointcutAdvisor。

测试：

```
public class DynamicProxyTest {

    @Test
    public void testAdvisor() throws Exception {
        WorldService worldService = new WorldServiceImpl();

        //Advisor是Pointcut和Advice的组合
        String expression = "execution(* org.springframework.test.service.WorldService.explode(..))";
        AspectJExpressionPointcutAdvisor advisor = new AspectJExpressionPointcutAdvisor();
        advisor.setExpression(expression);
        MethodBeforeAdviceInterceptor methodInterceptor = new MethodBeforeAdviceInterceptor(new WorldServiceBeforeAdvice());
        advisor.setAdvice(methodInterceptor);

        ClassFilter classFilter = advisor.getPointcut().getClassFilter();
        if (classFilter.matches(worldService.getClass())) {
            AdvisedSupport advisedSupport = new AdvisedSupport();
            TargetSource targetSource = new TargetSource(worldService);
            advisedSupport.setTargetSource(targetSource);
            advisedSupport.setMethodInterceptor((MethodInterceptor)
advisor.getAdvice());

advisedSupport.setMethodMatcher(advisor.getPointcut().getMethodMatcher());
//          advisedSupport.setProxyTargetClass(true);   //JDK or CGLIB

            WorldService proxy = (WorldService) new
ProxyFactory(advisedSupport).getProxy();
            proxy.explode();
        }
    }
}
```

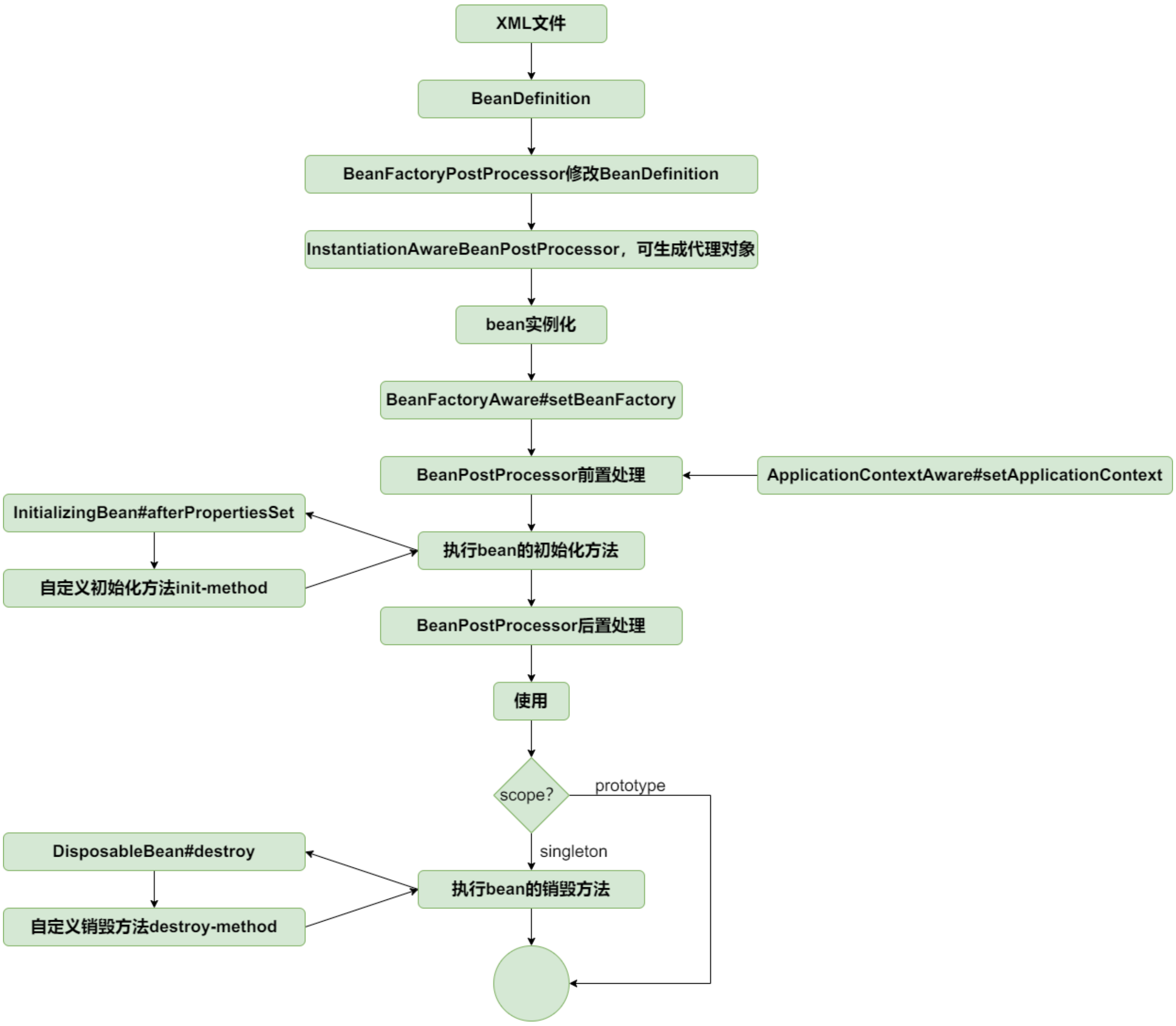
动态代理融入bean生命周期

> 代码分支：auto-proxy

结合前面讲解的bean的生命周期，BeanPostProcessor处理阶段可以修改和替换bean，正好可以在此阶段返回代理对象替换原对象。不过我们引入一种特殊的BeanPostProcessor——InstantiationAwareBeanPostProcessor，如果InstantiationAwareBeanPostProcessor处理阶段返回代理对象，会导致短路，不会继续走原来的创建bean的流程，具体实现查看AbstractAutowireCapableBeanFactory#resolveBeforeInstantiation。

DefaultAdvisorAutoProxyCreator是处理横切逻辑的织入返回代理对象的InstantiationAwareBeanPostProcessor实现类，当对象实例化时，生成代理对象并返回。

至此，bean的生命周期如下：


XML文件
BeanDefinition
BeanFactoryPostProcessor修改BeanDefinition
InstantiationAwareBeanPostProcessor，可生成代理对象
bean实例化
BeanFactoryAware#setBeanFactory
BeanPostProcessor前置处理
ApplicationContextAware#setApplicationContext
InitializingBean#afterPropertiesSet
执行bean的初始化方法
自定义初始化方法init-method
BeanPostProcessor后置处理
使用
scope?
prototype
singleton
DisposableBean#destroy
执行bean的销毁方法
自定义销毁方法destroy-method

测试：
auto-proxy.xml

```
<?xml version="1.0" encoding="UTF-8"?>
<beans xmlns="http://www.springframework.org/schema/beans"
       xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
       xmlns:context="http://www.springframework.org/schema/context"
       xsi:schemaLocation="http://www.springframework.org/schema/beans
             http://www.springframework.org/schema/beans/spring-beans.xsd
         http://www.springframework.org/schema/context
         http://www.springframework.org/schema/context/spring-context-4.0.xsd">

    <bean id="worldService"
class="org.springframework.test.service.WorldServiceImpl"/>

    <bean
class="org.springframework.aop.framework.autoproxy.DefaultAdvisorAutoProxyCreato
r"/>

    <bean id="pointcutAdvisor"
class="org.springframework.aop.aspectj.AspectJExpressionPointcutAdvisor">
        <property name="expression" value="execution(*
org.springframework.test.service.WorldService.explode(..))"/>
        <property name="advice" ref="methodInterceptor"/>
    </bean>


    <bean id="methodInterceptor"
class="org.springframework.aop.framework.adapter.MethodBeforeAdviceInterceptor">
        <property name="advice" ref="beforeAdvice"/>
    </bean>

    <bean id="beforeAdvice"
class="org.springframework.test.common.WorldServiceBeforeAdvice"/>

</beans>
```

```
public class AutoProxyTest {

    @Test
    public void testAutoProxy() throws Exception {
        ClassPathXmlApplicationContext applicationContext = new
ClassPathXmlApplicationContext("classpath:auto-proxy.xml");

        //获取代理对象
        WorldService worldService = applicationContext.getBean("worldService",
WorldService.class);
        worldService.explode();
    }
}
```

扩展篇

PropertyPlaceholderConfigurer

> 代码分支：property-placeholder-configurer

经常需要将配置信息配置在properties文件中，然后在XML文件中以占位符的方式引用。

实现思路很简单，在bean实例化之前，编辑BeanDefinition，解析XML文件中的占位符，然后用properties文件中的配置值替换占位符。而BeanFactoryPostProcessor具有编辑BeanDefinition的能力，因此PropertyPlaceholderConfigurer继承自BeanFactoryPostProcessor。

测试：
car.properties

```
brand=lamborghini
```

```
<?xml version="1.0" encoding="UTF-8"?>
<beans xmlns="http://www.springframework.org/schema/beans"
       xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
       xmlns:context="http://www.springframework.org/schema/context"
       xsi:schemaLocation="http://www.springframework.org/schema/beans
             http://www.springframework.org/schema/beans/spring-beans.xsd
         http://www.springframework.org/schema/context
         http://www.springframework.org/schema/context/spring-context-4.0.xsd">

    <bean
class="org.springframework.beans.factory.PropertyPlaceholderConfigurer">
        <property name="location" value="classpath:car.properties" />
    </bean>

    <bean id="car" class="org.springframework.test.bean.Car">
        <property name="brand" value="${brand}" />
    </bean>

</beans>
```

```
public class PropertyPlaceholderConfigurerTest {

    @Test
    public void test() throws Exception {
        ClassPathXmlApplicationContext applicationContext = new
ClassPathXmlApplicationContext("classpath:property-placeholder-configurer.xml");

        Car car = applicationContext.getBean("car", Car.class);
        assertThat(car.getBrand()).isEqualTo("lamborghini");
    }
}
```

包扫描

> 代码分支：package-scan

结合bean的生命周期，包扫描只不过是扫描特定注解的类，提取类的相关信息组装成BeanDefinition注册到容器中。

在XmlBeanDefinitionReader中解析`<context:component-scan />`标签，扫描类组装BeanDefinition然后注册到容器中的操作在ClassPathBeanDefinitionScanner#doScan中实现。

测试：

```
@Component
public class Car {

}
```

package-scan.xml

```
<?xml version="1.0" encoding="UTF-8"?>
<beans xmlns="http://www.springframework.org/schema/beans"
       xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
       xmlns:context="http://www.springframework.org/schema/context"
       xsi:schemaLocation="http://www.springframework.org/schema/beans
             http://www.springframework.org/schema/beans/spring-beans.xsd
         http://www.springframework.org/schema/context
         http://www.springframework.org/schema/context/spring-context-4.0.xsd">

    <context:component-scan base-package="org.springframework.test.bean"/>

</beans>
```

```
public class PackageScanTest {

    @Test
    public void testScanPackage() throws Exception {
        ClassPathXmlApplicationContext applicationContext = new
ClassPathXmlApplicationContext("classpath:package-scan.xml");

        Car car = applicationContext.getBean("car", Car.class);
        assertThat(car).isNotNull();
    }
}
```

@Value注解

> 代码分支：value-annotation

注解@Value和@Autowired通过BeanPostProcessor处理。InstantiationAwareBeanPostProcessor增加postProcessPropertyValues方法，在bean实例化之后设置属性之前执行，查看AbstractAutowireCapableBeanFactory#doCreateBean方法。

增加AutowiredAnnotationBeanPostProcessor用于处理注解@Value，@Autowired的处理在下一节实现，在ClassPathBeanDefinitionScanner#doScan将其添加到容器中。查看AutowiredAnnotationBeanPostProcessor#postProcessPropertyValues，其中字符解析器StringValueResolver在PropertyPlaceholderConfigurer中添加到BeanFactory中。

测试：

```
@Component
public class Car {

    @Value("${brand}")
    private String brand;
}
```

value-annotation.xml

```
<?xml version="1.0" encoding="UTF-8"?>
<beans xmlns="http://www.springframework.org/schema/beans"
       xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
       xmlns:context="http://www.springframework.org/schema/context"
       xsi:schemaLocation="http://www.springframework.org/schema/beans
             http://www.springframework.org/schema/beans/spring-beans.xsd
         http://www.springframework.org/schema/context
         http://www.springframework.org/schema/context/spring-context-4.0.xsd">

    <bean
class="org.springframework.beans.factory.PropertyPlaceholderConfigurer">
        <property name="location" value="classpath:car.properties" />
    </bean>

    <context:component-scan base-package="org.springframework.test.bean"/>

</beans>
```

car.properties

```
brand=lamborghini
```

```
public class ValueAnnotationTest {

    @Test
    public void testValueAnnotation() throws Exception {
        ClassPathXmlApplicationContext applicationContext = new
ClassPathXmlApplicationContext("classpath:value-annotation.xml");

        Car car = applicationContext.getBean("car", Car.class);
        assertThat(car.getBrand()).isEqualTo("lamborghini");
    }
}
```

@Autowired注解

> 代码分支：autowired-annotation

@Autowired注解的处理见AutowiredAnnotationBeanPostProcessor#postProcessPropertyValues

测试：

```
@Component
public class Car {

}

@Component
public class Person implements InitializingBean, DisposableBean {

    @Autowired
    private Car car;
}
```

autowired-annotation.xml

```
<?xml version="1.0" encoding="UTF-8"?>
<beans xmlns="http://www.springframework.org/schema/beans"
       xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
       xmlns:context="http://www.springframework.org/schema/context"
       xsi:schemaLocation="http://www.springframework.org/schema/beans
             http://www.springframework.org/schema/beans/spring-beans.xsd
         http://www.springframework.org/schema/context
         http://www.springframework.org/schema/context/spring-context-4.0.xsd">

    <context:component-scan base-package="org.springframework.test.bean"/>

</beans>
```

```
public class AutowiredAnnotationTest {

    @Test
    public void testAutowiredAnnotation() throws Exception {
        ClassPathXmlApplicationContext applicationContext = new
ClassPathXmlApplicationContext("classpath:autowired-annotation.xml");

        Person person = applicationContext.getBean(Person.class);
        assertThat(person.getCar()).isNotNull();
    }
}
```

bug fix：没有为代理bean设置属性（discovered and fixed by @kerwin89）

> 代码分支: populate-proxy-bean-with-property-values

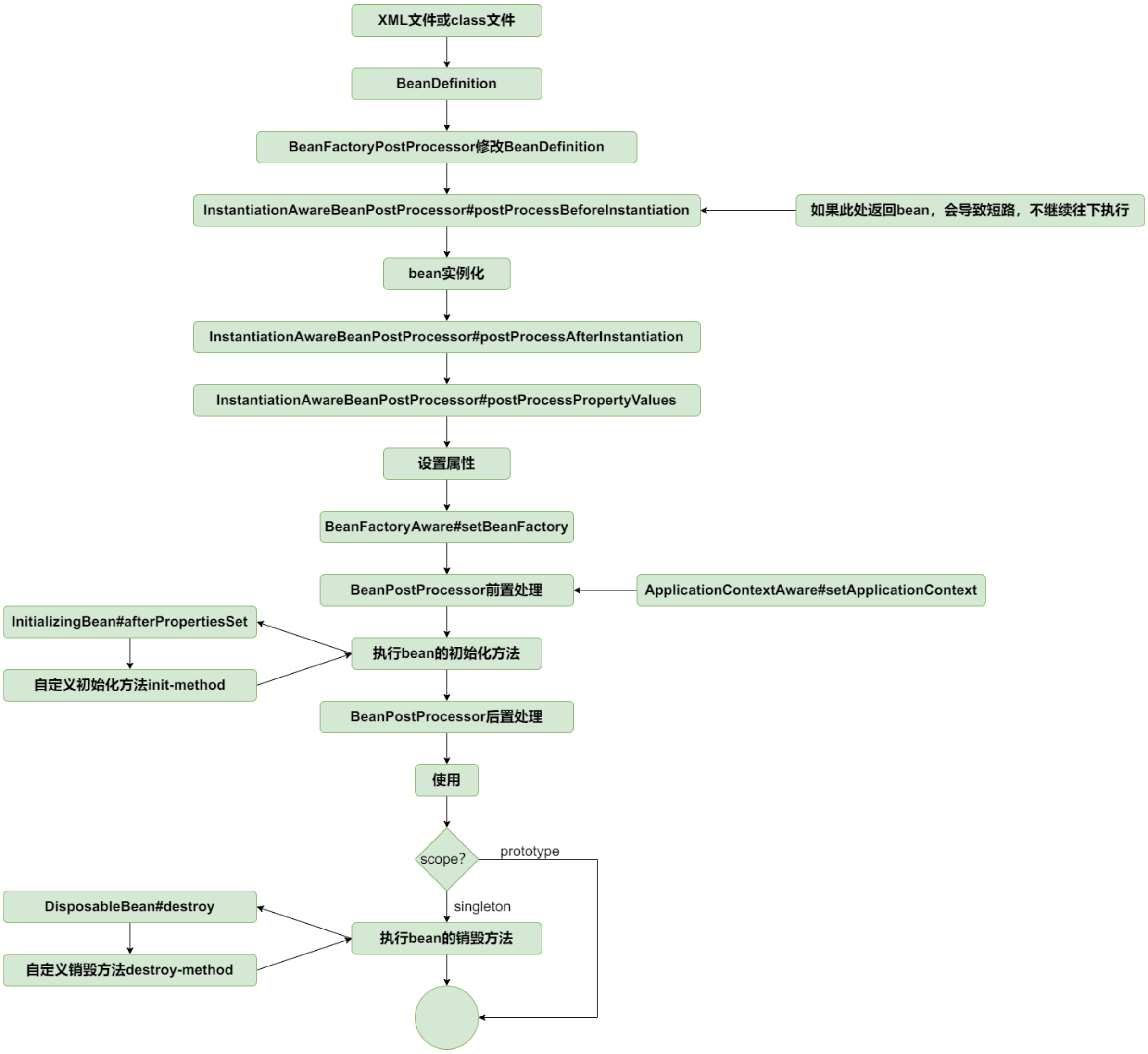
问题现象：没有为代理bean设置属性

问题原因：织入逻辑在InstantiationAwareBeanPostProcessor#postProcessBeforeInstantiation中执行，而该方法如果返回非null，会导致"短路"，不会执行后面的设置属性逻辑。因此如果该方法中返回代理bean后，不会为代理bean设置属性。

修复方案：跟spring保持一致，将织入逻辑迁移到BeanPostProcessor#postProcessAfterInitialization，即将DefaultAdvisorAutoProxyCreator#postProcessBeforeInstantiation的内容迁移到DefaultAdvisorAutoProxyCreator#postProcessAfterInitialization中。

顺便完善spring的扩展机制，为InstantiationAwareBeanPostProcessor增加postProcessAfterInstantiation方法，该方法在bean实例化之后设置属性之前执行。

至此，bean的生命周期比较完整了，如下：


XML文件或class文件
BeanDefinition
BeanFactoryPostProcessor修改BeanDefinition
InstantiationAwareBeanPostProcessor#postProcessBeforeInstantiation
如果此处返回bean，会导致短路，不继续往下执行
bean实例化
InstantiationAwareBeanPostProcessor#postProcessAfterInstantiation
InstantiationAwareBeanPostProcessor#postProcessPropertyValues
设置属性
BeanFactoryAware#setBeanFactory
BeanPostProcessor前置处理
ApplicationContextAware#setApplicationContext
InitializingBean#afterPropertiesSet
执行bean的初始化方法
自定义初始化方法init-method
BeanPostProcessor后置处理
使用
scope?
prototype
singleton
DisposableBean#destroy
执行bean的销毁方法
自定义销毁方法destroy-method

测试：
populate-proxy-bean-with-property-values.xml

```
<?xml version="1.0" encoding="UTF-8"?>
<beans xmlns="http://www.springframework.org/schema/beans"
       xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
       xmlns:context="http://www.springframework.org/schema/context"
       xsi:schemaLocation="http://www.springframework.org/schema/beans
             http://www.springframework.org/schema/beans/spring-beans.xsd
         http://www.springframework.org/schema/context
         http://www.springframework.org/schema/context/spring-context-4.0.xsd">

    <bean id="worldService"
class="org.springframework.test.service.WorldServiceImpl">
        <property name="name" value="earth"/>
    </bean>
    <bean class="org.springframework.aop.framework.autoproxy.DefaultAdvisorAutoProxyCreator"/>

    <bean id="pointcutAdvisor" class="org.springframework.aop.aspectj.AspectJExpressionPointcutAdvisor">
        <property name="expression" value="execution(* org.springframework.test.service.WorldService.explode(..))"/>
        <property name="advice" ref="methodInterceptor"/>
    </bean>


    <bean id="methodInterceptor" class="org.springframework.aop.framework.adapter.MethodBeforeAdviceInterceptor">
        <property name="advice" ref="beforeAdvice"/>
    </bean>

    <bean id="beforeAdvice" class="org.springframework.test.common.WorldServiceBeforeAdvice"/>

</beans>
```

```
public class WorldServiceImpl implements WorldService {

    private String name;

    @Override
    public void explode() {
        System.out.println("The " + name + " is going to explode");
    }

    //setter and getter
}
```

```
public class AutoProxyTest {

    @Test
    public void testPopulateProxyBeanWithPropertyValues() throws Exception {
        ClassPathXmlApplicationContext applicationContext = new ClassPathXmlApplicationContext("classpath:populate-proxy-bean-with-property-values.xml");

        //获取代理对象
        WorldService worldService = applicationContext.getBean("worldService", WorldService.class);
        worldService.explode();
        assertThat(worldService.getName()).isEqualTo("earth");
    }
}
```

类型转换（一）

> 代码分支：type-conversion-first-part

spring在org.springframework.core.convert.converter包中定义了三种类型转换器接口：Converter、ConverterFactory、GenericConverter。

一、Converter

```
public interface Converter<S, T> {

    /**
     * 类型转换
     */
    T convert(S source);
}
```

Converter能将S类型的对象转换为T类型的对象，比如将String类型的对象转换为Integer类型的对象的实现类：

```
public class StringToIntegerConverter implements Converter<String, Integer> {
    @Override
    public Integer convert(String source) {
        return Integer.valueOf(source);
    }
}
```

使用：

```
Integer num = new StringToIntegerConverter().convert("8888");
```

二、ConverterFactory

```
public interface ConverterFactory<S, R> {

    <T extends R> Converter<S, T> getConverter(Class<T> targetType);
}
```

Converter<S,T>接口适合一对一的类型转换，如果要将String类型转换为Ineger/Long/Float/Double/Decimal等类型，就要实现一系列的StringToInteger/StringToLongConverter/StringToFloatConverter转换器，非常不优雅。

ConverterFactory接口则适合一对多的类型转换，可以将一种类型转换为另一种类型及其子类。比如将String类型转换为Ineger/Long/Float/Double/Decimal等Number类型时，只需定义一个ConverterFactory转换器：

```
public class StringToNumberConverterFactory implements ConverterFactory<String,
Number> {

    @Override
    public <T extends Number> Converter<String, T> getConverter(Class<T>
targetType) {
        return new StringToNumber<T>(targetType);
    }
    private static final class StringToNumber<T extends Number> implements
Converter<String, T> {

        private final Class<T> targetType;

        public StringToNumber(Class<T> targetType) {
            this.targetType = targetType;
        }

        @Override
        public T convert(String source) {
            if (source.length() == 0) {
                return null;
            }

            if (targetType.equals(Integer.class)) {
                return (T) Integer.valueOf(source);
            } else if (targetType.equals(Long.class)) {
                return (T) Long.valueOf(source);
            }
            //TODO 其他数字类型

            else {
                throw new IllegalArgumentException(
                        "Cannot convert String [" + source + "] to target class
[" + targetType.getName() + "]");
            }
        }
    }

}
```

使用：

```
StringToNumberConverterFactory converterFactory = new
StringToNumberConverterFactory();
Converter<String, Integer> stringToIntegerConverter =
converterFactory.getConverter(Integer.class);
Integer num = stringToIntegerConverter.convert("8888");
```

三、GenericConverter

```
public interface GenericConverter {

    Set<ConvertiblePair> getConvertibleTypes();

    Object convert(Object source, Class sourceType, Class targetType);
}
```

String类型转换为Boolean类型的实现类：

```
public class StringToBooleanConverter implements GenericConverter {
    @Override
    public Set<ConvertiblePair> getConvertibleTypes() {
        return Collections.singleton(new ConvertiblePair(String.class,
Boolean.class));
    }

    @Override
    public Object convert(Object source, Class sourceType, Class targetType) {
        return Boolean.valueOf((String) source);
    }
}
```

使用:

```
Boolean flag = new StringToBooleanConverter().convert("true", String.class,
Boolean.class);
```

ConversionService是类型转换体系的核心接口，将以上三种类型转换器整合到一起，GenericConversionService是其实现类，DefaultConversionService在GenericConversionService的基础上添加内置转换器。

测试见TypeConversionFirstPartTest。

类型转换（二）

> 代码分支：type-conversion-second-part

上一节实现了spring中的类型转换体系，本节将类型转换的能力整合到容器中。

为了方便使用，提供了创建ConversionService的FactoryBean——ConversionServiceFactoryBean。

如果有定义ConversionService，在AbstractApplicationContext#finishBeanFactoryInitialization方法中设置到容器中。

类型转换的时机有两个:

- 为bean填充属性时，见AbstractAutowireCapableBeanFactory#applyPropertyValues
- 处理@Value注解时，见AutowiredAnnotationBeanPostProcessor#postProcessPropertyValues

你可能会有疑问，如果没有定义ConversionService，是怎么进行基本类型的转换的？其实spring为了向下兼容保留了一套比较旧的类型转换机制，没有定义ConversionService时会使用其进行基本类型的转换工作，不必关注旧的类型转换机制。

测试:

```
public class Car {

    private int price;

    private LocalDate produceDate;
}
```

```
public class StringToLocalDateConverter implements Converter<String, LocalDate>
{

    private final DateTimeFormatter DATE_TIME_FORMATTER;

    public StringToLocalDateConverter(String pattern) {
        DATE_TIME_FORMATTER = DateTimeFormatter.ofPattern(pattern);
    }

    @Override
    public LocalDate convert(String source) {
        return LocalDate.parse(source, DATE_TIME_FORMATTER);
    }
}
```

type-conversion-second-part.xml

```
<?xml version="1.0" encoding="UTF-8"?>
<beans xmlns="http://www.springframework.org/schema/beans"
       xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
       xmlns:context="http://www.springframework.org/schema/context"
       xsi:schemaLocation="http://www.springframework.org/schema/beans
             http://www.springframework.org/schema/beans/spring-beans.xsd
         http://www.springframework.org/schema/context
         http://www.springframework.org/schema/context/spring-context-4.0.xsd">

    <bean id="car" class="org.springframework.test.bean.Car">
        <property name="price" value="1000000"/>
        <property name="produceDate" value="2021-01-01"/>
    </bean>

    <bean id="conversionService"
class="org.springframework.context.support.ConversionServiceFactoryBean">
        <property name="converters" ref="converters"/>
    </bean>

    <bean id="converters"
class="org.springframework.test.common.ConvertersFactoryBean"/>

</beans>
```

```
public class TypeConversionSecondPartTest {

    @Test
    public void testConversionService() throws Exception {
        ClassPathXmlApplicationContext applicationContext = new
ClassPathXmlApplicationContext("classpath:type-conversion-second-part.xml");

        Car car = applicationContext.getBean("car", Car.class);
        assertThat(car.getPrice()).isEqualTo(1000000);
        assertThat(car.getProduceDate()).isEqualTo(LocalDate.of(2021, 1, 1));
    }
}
```

高级篇

解决循环依赖问题（一）：没有代理对象

> 代码分支：circular-reference-without-proxy-bean

虽然放在高级篇，其实解决循环依赖问题的方法非常简单。

先理解spring中为什么会有循环依赖的问题。比如如下的代码

```
public class A {

    private B b;

    //getter and setter
}
```

```
public class B {

    private A a;

    //getter and setter
}
```

```
<beans>
    <bean id="a" class="org.springframework.test.bean.A">
        <property name="b" ref="b"/>
    </bean>
    <bean id="b" class="org.springframework.test.bean.B">
        <property name="a" ref="a"/>
    </bean>
</beans>
```

A依赖B，B又依赖A，循环依赖。容器加载时会执行依赖流程：

- 实例化A，发现依赖B，然后实例化B
- 实例化B，发现依赖A，然后实例化A
- 实例化A，发现依赖B，然后实例化B
- ...

死循环直至栈溢出。

解决该问题的关键在于何时将实例化后的bean放进容器中，设置属性前还是设置属性后。现有的执行流程，bean实例化后并且设置属性后会被放进singletonObjects单例缓存中。如果我们调整一下顺序，当bean实例化后就放进singletonObjects单例缓存中，提前暴露引用，然后再设置属性，就能解决上面的循环依赖问题，执行流程变为：

- 步骤一：getBean(a)，检查singletonObjects是否包含a，singletonObjects不包含a，实例化A放进singletonObjects，设置属性b，发现依赖B，尝试getBean(b)
- 步骤二：getBean(b)，检查singletonObjects是否包含b，singletonObjects不包含b，实例化B放进singletonObjects，设置属性a，发现依赖A，尝试getBean(a)
- 步骤三：getBean(a)，检查singletonObjects是否包含a，singletonObjects包含a，返回a
- 步骤四：步骤二中的b拿到a，设置属性a，然后返回b

- 步骤五：步骤一中的a拿到b，设置属性b，然后返回a

可见调整bean放进singletonObjects（人称一级缓存）的时机到bean实例化后即可解决循环依赖问题。但为了和spring保持一致，我们增加一个二级缓存earlySingletonObjects，在bean实例化后将bean放进earlySingletonObjects中（见AbstractAutowireCapableBeanFactory#doCreateBean方法第6行），getBean()时检查一级缓存singletonObjects和二级缓存earlySingletonObjects中是否包含该bean，包含则直接返回（见AbstractBeanFactory#getBean第1行）。

单测见CircularReferenceWithoutProxyBeanTest#testCircularReference。

增加二级缓存，不能解决有代理对象时的循环依赖。原因是放进二级缓存earlySingletonObjects中的bean是实例化后的bean，而放进一级缓存singletonObjects中的bean是代理对象（代理对象在BeanPostProcessor#postProcessAfterInitialization中返回），两个缓存中的bean不一致。比如上面的例子，如果A被代理，那么B拿到的a是实例化后的A，而a是被代理后的对象，即b.getA() != a，见单测CircularReferenceWithProxyBeanTest。

下一节填坑。

解决循环依赖问题（二）：有代理对象

> 代码分支：circular-reference-with-proxy-bean

解决有代理对象时的循环依赖问题，需要提前暴露代理对象的引用，而不是暴露实例化后的bean的引用（这是上节的遗留问题的原因，应该提前暴露A的代理对象的引用）。

spring中用singletonFactories（一般称第三级缓存）解决有代理对象时的循环依赖问题。在实例化后提前暴露代理对象的引用（见AbstractAutowireCapableBeanFactory#doCreateBean方法第6行）。

getBean()时依次检查一级缓存singletonObjects、二级缓存earlySingletonObjects和三级缓存singletonFactories中是否包含该bean。如果三级缓存中包含该bean，则挪至二级缓存中，然后直接返回该bean。见AbstractBeanFactory#getBean方法第1行。

最后将代理bean放进一级缓存singletonObjects，见AbstractAutowireCapableBeanFactory第104行。

单测见CircularReferenceWithProxyBeanTest。

支持懒加载和多切面增强(By @zqczgl)

懒加载

> 代码分支：lazy-init-and-multi-advice

事实上，并不是所有的bean在初始化容器的时候都会创建。随着项目规模的不断扩大，bean的数目也越来越多。如果每次启动容器都需要加载大量的bean，这无疑会带来大量的资源浪费。所有spring提供了懒加载机制，我们可以将我们认为暂时用不到的bean设为懒加载，这样只有在我们需要这个bean的时候这个bean才会被创建。

测试

lazy-test.xml

```
//只有当bean是单例且不为懒加载才会被创建
public void preInstantiateSingletons() throws BeansException {
        beanDefinitionMap.forEach((beanName, beanDefinition) -> {
            if(beanDefinition.isSingleton()&&!beanDefinition.isLazyInit()){
                getBean(beanName);
            }
        });
    }
```

```
public class LazyInitTest {
    @Test
    public void testLazyInit() throws InterruptedException {
        ClassPathXmlApplicationContext applicationContext = new ClassPathXmlApplicationContext("classpath:lazy-test.xml");
        System.out.println(System.currentTimeMillis()+":applicationContext-over");
        TimeUnit.SECONDS.sleep(1);
        Car c= (Car) applicationContext.getBean("car");
        c.showTime();//显示bean的创建时间
    }
}
```

```
<?xml version="1.0" encoding="UTF-8"?>
<beans xmlns="http://www.springframework.org/schema/beans"
       xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
       xsi:schemaLocation="http://www.springframework.org/schema/beans http://www.springframework.org/schema/beans/spring-beans.xsd">
    <bean id="car" class="org.springframework.test.bean.Car" lazyInit="true" init-method="init">
        <property name="brand" value="porsche"/>
    </bean>
</beans>
```

关闭懒加载的输出:

```
1671698959957:applicationContext-over
1671698959951:bean create
```

开启懒加载:

```
1671699030293:applicationContext-over
1671699031328:bean create
```

可以清楚的看到开启和不开启懒加载bean的创建时机的差异

多个切面匹配同一方法

> 代码分支: lazy-init-and-multi-advice

虽然在前面我们完成了对方法的增强，但并不完美。我们的目前的代码只能支持对方法的单个增强。作为spring的核心功能如果不支持多切面的话有点太别扭了。spring利用了拦截器链来完成了对多个切面的支持。

ProxyFactory

让我们从ProxyFactory开始，来看一下代理对象的整个创建流程。至于为什么从ProxyFactory开，这是因为代理对象最终是用ProxyFactory的getProxy()函数来获得的。

```
public class ProxyFactory extends AdvisedSupport{


    public ProxyFactory() {
    }

    public Object getProxy() {
        return createAopProxy().getProxy();
    }

    private AopProxy createAopProxy() {
        if
(this.isProxyTargetClass()||this.getTargetSource().getTargetClass().length==0) {
            return new CglibAopProxy(this);
        }
        return new JdkDynamicAopProxy(this);
    }
}
```

为了更贴合spring的实现，这里更改了ProxyFactory使其继承了AdvisedSupport，正如spring源码中做的那样。

基于JDK动态代理

ProxyFactory只是简单的做了下选择，当我们设置proxyTargetClass属性或者被代理对象没有接口时会调用cjlib动态代理，否则调用jdk动态代理。二者实现并没有太大区别，这里只贴出jdk动态代理的实现。

```
    public Object getProxy() {
        return Proxy.newProxyInstance(getClass().getClassLoader(),
advised.getTargetSource().getTargetClass(), this);
    }

    @Override
    public Object invoke(Object proxy, Method method, Object[] args) throws
Throwable {
        // 获取目标对象
        Object target=advised.getTargetSource().getTarget();
        Class<?> targetClass = target.getClass();
        Object retVal = null;
        // 获取拦截器链
        List<Object> chain =
this.advised.getInterceptorsAndDynamicInterceptionAdvice(method, targetClass);
        if(chain==null||chain.isEmpty()){
            return method.invoke(target, args);
        }else{
            // 将拦截器统一封装成ReflectiveMethodInvocation
            MethodInvocation invocation =
                    new ReflectiveMethodInvocation(proxy, target, method, args,
targetClass, chain);
            // Proceed to the joinpoint through the interceptor chain.
            // 执行拦截器链
            retVal = invocation.proceed();
        }
        return retVal;
    }
```

jdk动态代理可以分为获取拦截器链，将拦截器统一封装成ReflectiveMethodInvocation，执行拦截器链三部分。我们来逐一看一下这三部分。

1.获取拦截器链

首先将获取到所有与当前method匹配的advice(增强)，跟踪getInterceptorsAndDynamicInterceptionAdvice代码，我们发现Spring AOP也使用缓存进行提高性能，如果该方法已经获取过拦截器，则直接取缓存，否则通过advisorChainFactory获取拦截器链。AdvisorChainFactory是用来获得拦截器链接口。它的一个实现类为DefaultAdvisorChainFactory

AdvisedSupport#getInterceptorsAndDynamicInterceptionAdvice：

```
    public List<Object> getInterceptorsAndDynamicInterceptionAdvice(Method
method, Class<?> targetClass) {
        Integer cacheKey=method.hashCode();
        List<Object> cached = this.methodCache.get(cacheKey);
        if (cached == null) {
            cached =
this.advisorChainFactory.getInterceptorsAndDynamicInterceptionAdvice(
                    this, method, targetClass);
            this.methodCache.put(cacheKey, cached);
        }
        return cached;
    }
```

整体代码并不复杂，首先获取所有Advisor(切面)，通过pointcutAdvisor.getPointcut().getClassFilter().matches(actualClass)校验当前代理对象是否匹配该Advisor，再通过pointcutAdvisor.getPointcut().getMethodMatcher()校验是否匹配当前调用method。如果通过校验，则提取advisor中的interceptors增强，添加到interceptorList中。这里可能有读者会疑惑，我们明明是要获取MethodInterceptor，可AdvisedSupport的getAdvice()返回的是Advice(增强),其实如果我们点开MethodInterceptor的源码，我们会发现MethodInterceptor继承了Interceptor接口，而Interceptor又继承了Advice接口。因为这里的Advice和MethodInterceptor我们都是用的AOP联盟的接口，所以特此说明一下。

DefultAdvisorChainFactory#getInterceptorsAndDynamicInterceptionAdvice

```
public List<Object> getInterceptorsAndDynamicInterceptionAdvice(AdvisedSupport
config, Method method, Class<?> targetClass) {
        Advisor[] advisors = config.getAdvisors().toArray(new Advisor[0]);
        List<Object> interceptorList = new ArrayList<>(advisors.length);
        Class<?> actualClass = (targetClass != null ? targetClass :
method.getDeclaringClass());
```

```
        for (Advisor advisor : advisors) {
            if (advisor instanceof PointcutAdvisor) {
                // Add it conditionally.
                PointcutAdvisor pointcutAdvisor = (PointcutAdvisor) advisor;
                // 校验当前Advisor是否适用于当前对象
                if
(pointcutAdvisor.getPointcut().getClassFilter().matches(actualClass)) {
                    MethodMatcher mm =
pointcutAdvisor.getPointcut().getMethodMatcher();
                    boolean match;
                    // 校验Advisor是否应用到当前方法上
                    match = mm.matches(method,actualClass);
                    if (match) {
                        MethodInterceptor interceptor = (MethodInterceptor)
advisor.getAdvice();
                            interceptorList.add(interceptor);
                    }
                }
            }
        }
        return interceptorList;
    }
```

2.将拦截器封装成ReflectiveMethodInvocation

这里也是重写了ReflectiveMethodInvocation的实现，来支持多切面。

```
    public ReflectiveMethodInvocation(Object proxy,Object target, Method method,
Object[] arguments,Class<?> targetClass,List<Object> chain) {
        this.proxy=proxy;
        this.target = target;
        this.method = method;
        this.arguments = arguments;
        this.targetClass=targetClass;
        this.interceptorsAndDynamicMethodMatchers=chain;
    }
```

3.执行拦截器链

spring能够保证多个切面同时匹配同一方法的而不出现乱序的关键就在下面一段代码了。

ReflectiveMethodInvocation#proceed()

```
    public Object proceed() throws Throwable {
        // 初始currentInterceptorIndex为-1，每调用一次proceed就把
currentInterceptorIndex+1
        if (this.currentInterceptorIndex ==
this.interceptorsAndDynamicMethodMatchers.size() - 1) {
            // 当调用次数 = 拦截器个数时
            // 触发当前method方法
            return method.invoke(this.target, this.arguments);
        }

        Object interceptorOrInterceptionAdvice =

this.interceptorsAndDynamicMethodMatchers.get(++this.currentInterceptorIndex);
        // 普通拦截器，直接触发拦截器invoke方法
        return ((MethodInterceptor)
interceptorOrInterceptionAdvice).invoke(this);
    }
```

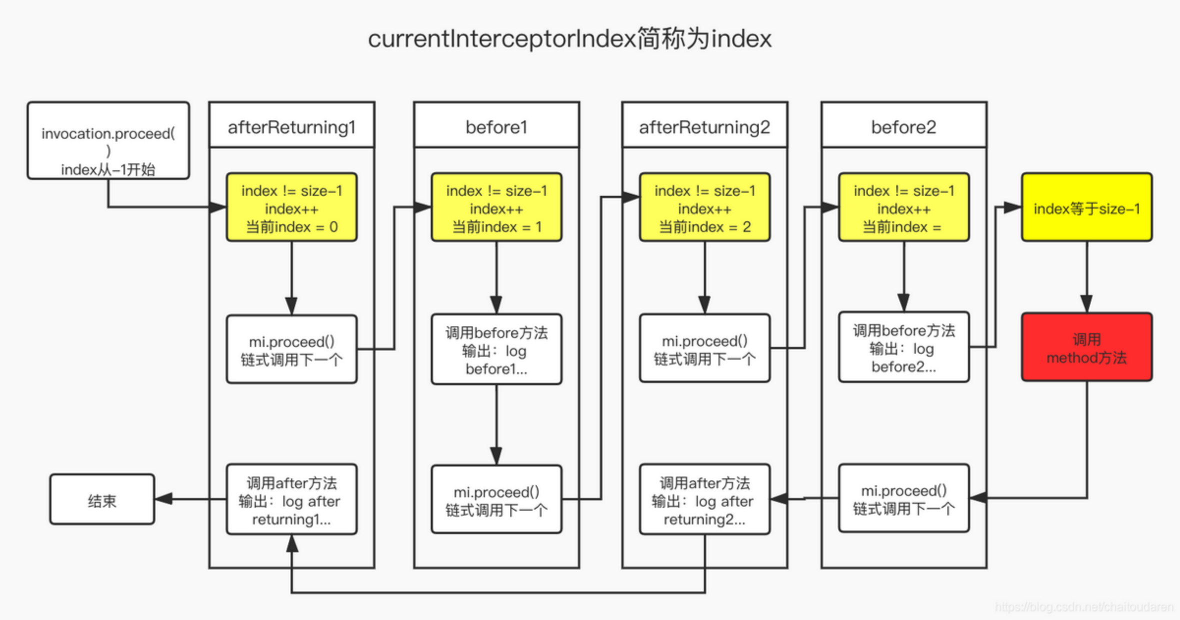
我们看到，MethodInvocation只是简单的将拦截器链的所有拦截器一一执行，最后再触发当前的method方法。这是很简单高效的方法，但问题是我们希望某些增强比如AfterReturningAdvice能够在方法执行完才被执行，这就涉及到不同增强的执行顺序的问题了。而MethodInvocation显然没有考虑顺序的问题，一个AfterReturningAdvice很可能在BeforeAdvice之前被调用。那么该如何保证顺序问题呢?

答案是，控制增强的调用顺序其实由每个拦截器负责，所以我们需要分析`MethodBeforeAdviceInterceptor`和`AfterReturningAdviceInterceptor`

```
public class MethodBeforeAdviceInterceptor implements MethodInterceptor,
BeforeAdvice {

    private MethodBeforeAdvice advice;

    public MethodBeforeAdviceInterceptor() {
    }

    public MethodBeforeAdviceInterceptor(MethodBeforeAdvice advice) {
        this.advice = advice;
    }

    public void setAdvice(MethodBeforeAdvice advice) {
        this.advice = advice;
    }

    @Override
    public Object invoke(MethodInvocation mi) throws Throwable {
        this.advice.before(mi.getMethod(), mi.getArguments(), mi.getThis());
        return mi.proceed();
    }
}
```

```
package org.springframework.aop.framework.adapter;

import org.aopalliance.intercept.MethodInterceptor;
import org.aopalliance.intercept.MethodInvocation;
import org.springframework.aop.AfterAdvice;
import org.springframework.aop.AfterReturningAdvice;

/**
 * @author zqc
 * @date 2022/12/20
 */
public class AfterReturningAdviceInterceptor implements MethodInterceptor,
AfterAdvice {

    private  AfterReturningAdvice advice;

    public AfterReturningAdviceInterceptor() {
    }

    public AfterReturningAdviceInterceptor(AfterReturningAdvice advice) {
        this.advice = advice;
    }


    @Override
    public Object invoke(MethodInvocation mi) throws Throwable {
        Object retVal = mi.proceed();
        this.advice.afterReturning(retVal, mi.getMethod(), mi.getArguments(),
mi.getThis());
        return retVal;
    }
}
```

看了源码大家应该就清楚了，拦截器链执行的顺序正时在各个拦截器的`invoke`方法中实现的。`before`会先执行`advice`增强方法再链式调用，这个比较好理解而`after`则是先执行链式调用，再调用`advice`增强方法，也就是一个递归的过程。和二叉树的遍历有些异曲同工之处。



测试

！！！！！！！注意，使用过高版本的java可以因为java版本和cjlib冲突导致报错。建议使用java8进行测试

```java
public class WorldServiceImpl implements WorldService {

    private String name;

    @Override
    public void explode() {
        System.out.println("The " + name + " is going to explode");
    }

    @Override
    public String getName() {
        return name;
    }

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

前置增强：

```java
public class WorldServiceBeforeAdvice implements MethodBeforeAdvice {

    @Override
    public void before(Method method, Object[] args, Object target) throws Throwable {
        System.out.println("BeforeAdvice: do something before the earth explodes");
    }
}
```

后置返回增强：

```java
public class WorldServiceAfterReturnAdvice implements AfterReturningAdvice {
    @Override
    public void afterReturning(Object returnValue, Method method, Object[] args, Object target) throws Throwable {
        System.out.println("AfterAdvice: do something after the earth explodes");
    }
}
```

测试代码：

```java
public class ProxyFactoryTest {
    @Test
    public void testAdvisor() throws Exception {
        WorldService worldService = new WorldServiceImpl();
        //Advisor是Pointcut和Advice的组合
        String expression = "execution(*
org.springframework.test.service.WorldService.explode(..))";
        //第一个切面
        AspectJExpressionPointcutAdvisor advisor = new
AspectJExpressionPointcutAdvisor();
        advisor.setExpression(expression);
        MethodBeforeAdviceInterceptor methodInterceptor = new
MethodBeforeAdviceInterceptor(new WorldServiceBeforeAdvice());
        advisor.setAdvice(methodInterceptor);
        //第二个切面
        AspectJExpressionPointcutAdvisor advisor1=new
AspectJExpressionPointcutAdvisor();
        advisor1.setExpression(expression);
        AfterReturningAdviceInterceptor afterReturningAdviceInterceptor=new
AfterReturningAdviceInterceptor(new WorldServiceAfterReturnAdvice());
        advisor1.setAdvice(afterReturningAdviceInterceptor);
        //通过ProxyFactory来获得代理
        ProxyFactory factory = new ProxyFactory();
        TargetSource targetSource = new TargetSource(worldService);
        factory.setTargetSource(targetSource);
        factory.setProxyTargetClass(true);
        factory.addAdvisor(advisor);
        factory.addAdvisor(advisor1);
        WorldService proxy = (WorldService) factory.getProxy();
        proxy.explode();
    }
}
```

输出：

```
BeforeAdvice: do something before the earth explodes
The null is going to explode
AfterAdvice: do something after the earth explodes

进程已结束，退出代码为 0
```

多切面动态代理融入bean生命周期

```
    public void testAutoProxy() throws Exception {
        ClassPathXmlApplicationContext applicationContext = new
ClassPathXmlApplicationContext("classpath:auto-proxy.xml");

        //获取代理对象
        WorldService worldService = applicationContext.getBean("worldService",
WorldService.class);
        worldService.explode();
    }
```

auto-proxy.xml:

```
<?xml version="1.0" encoding="UTF-8"?>
<beans xmlns="http://www.springframework.org/schema/beans"
```

```
       xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
       xmlns:context="http://www.springframework.org/schema/context"
       xsi:schemaLocation="http://www.springframework.org/schema/beans
             http://www.springframework.org/schema/beans/spring-beans.xsd
         http://www.springframework.org/schema/context
         http://www.springframework.org/schema/context/spring-context-4.0.xsd">

    <bean id="worldService"
class="org.springframework.test.service.WorldServiceImpl"/>

    <bean
class="org.springframework.aop.framework.autoproxy.DefaultAdvisorAutoProxyCreato
r"/>

    <bean id="pointcutAdvisor"
class="org.springframework.aop.aspectj.AspectJExpressionPointcutAdvisor">
        <property name="expression" value="execution(*
org.springframework.test.service.WorldService.explode(..))"/>
        <property name="advice" ref="methodInterceptor"/>
    </bean>
    <bean id="pointcutAdvisor2"
class="org.springframework.aop.aspectj.AspectJExpressionPointcutAdvisor">
        <property name="expression" value="execution(*
org.springframework.test.service.WorldService.explode(..))"/>
        <property name="advice" ref="methodInterceptor2"/>
    </bean>

    <bean id="methodInterceptor"
class="org.springframework.aop.framework.adapter.MethodBeforeAdviceInterceptor">
        <property name="advice" ref="beforeAdvice"/>
    </bean>
    <bean id="methodInterceptor2"
class="org.springframework.aop.framework.adapter.AfterReturningAdviceInterceptor
">
        <property name="advice" ref="afterAdvice"/>
    </bean>
    <bean id="afterAdvice"
class="org.springframework.test.common.WorldServiceAfterReturnAdvice"/>
    <bean id="beforeAdvice"
class="org.springframework.test.common.WorldServiceBeforeAdvice"/>

</beans>
```

输出：

```
BeforeAdvice: do something before the earth explodes
The null is going to explode
AfterAdvice: do something after the earth explodes

进程已结束，退出代码为 0
```

至此，我们已经解决多切面匹配同一方法的问题。