Spring源码

BeanPostProcessor与BeanFactoryPostProcessor

- BeanPostProcessor在Spring容器初始化bean之前和初始化bean之后，干预bean的初始化行为；
- BeanFactoryPostProcessor是spring容器注册BeanDefinition时，用来干预BeanDefinition的行为；

FactoryBean 与BeanFactory

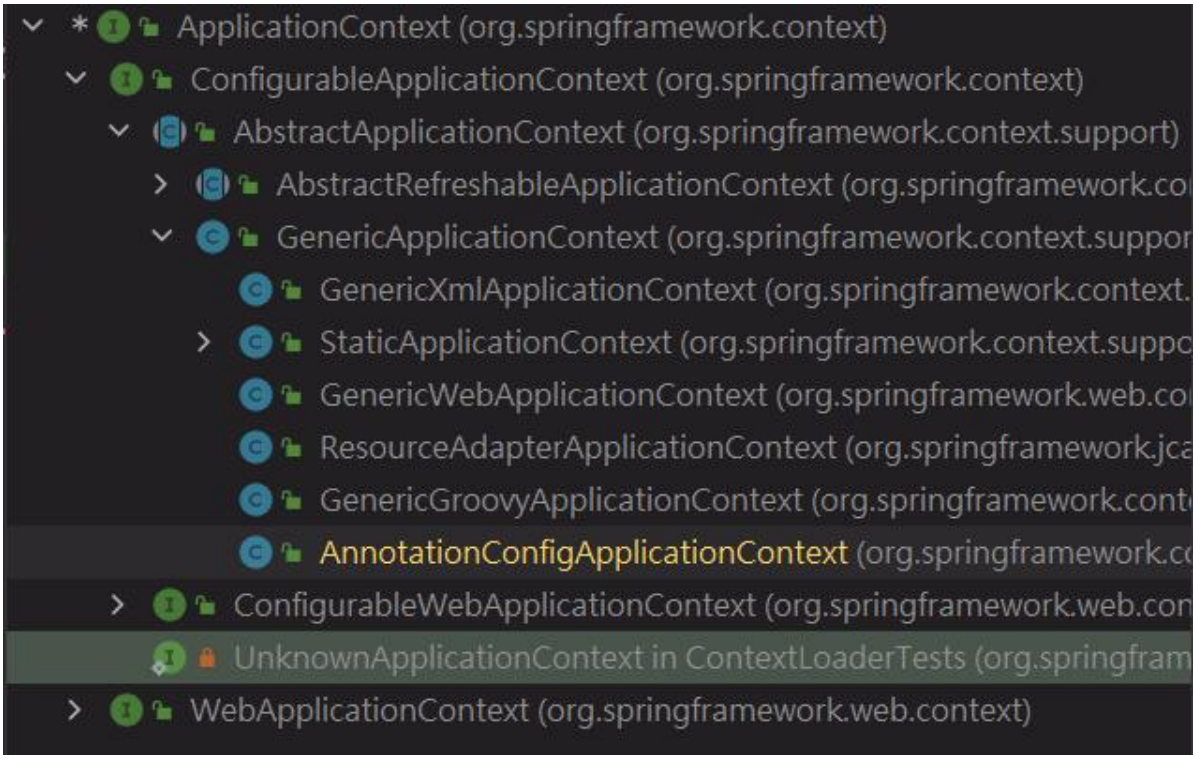
- FactoryBean是工厂bean，获取对象时候或调getObject（）方法返回对象；
- BeanFactory是spring容器；

IOC:

1、创建AnnotationconfigApplicationContext

```
ApplicationContext context = new
AnnotationConfigApplicationContext(SpringConfig.class);
```

- ApplicationContext接口：



- 继承关系： `AnnotationConfigApplicationContext` extends `GenericApplicationContext` 继承 `AbstractApplicationContext`（静态代码块解决了一个问题）
- 创建对象共有3步

```
public AnnotationConfigApplicationContext(Class<?>... componentClasses) {
    //注释配置应用程序上下文
        this();
        register(componentClasses);
        refresh();
    }
```

-

1.1、this（）

- 第一点：主要是spring内部加载了5个BeanDefinition对象（就是对bean的描述）
- BeanDefinition 是定义 Bean 的配置元信息接口，包含：

Bean 的类名
设置父 bean 名称、是否为 primary、
Bean 行为配置信息，作用域、自动绑定模式、生命周期回调、延迟加载、初始方法、销毁方法等
Bean 之间的依赖设置，dependencies
构造参数、属性设置
BeanDefinition 表示bean的定义，spring根据BeanDefinition 来创建bean对象

来自@Bean @Component等 **mybean类===>java对象 ===> spring bean的描述（BeanDefinition）==>变为spring的Bean**

- **1、父类中创建了`GenericApplicationContext` beanFactory**

> 1、创建 beanFactory 2、spring内部加载了5个BeanDefinition：就是对bean的描述； 3、放置了@Compment注解

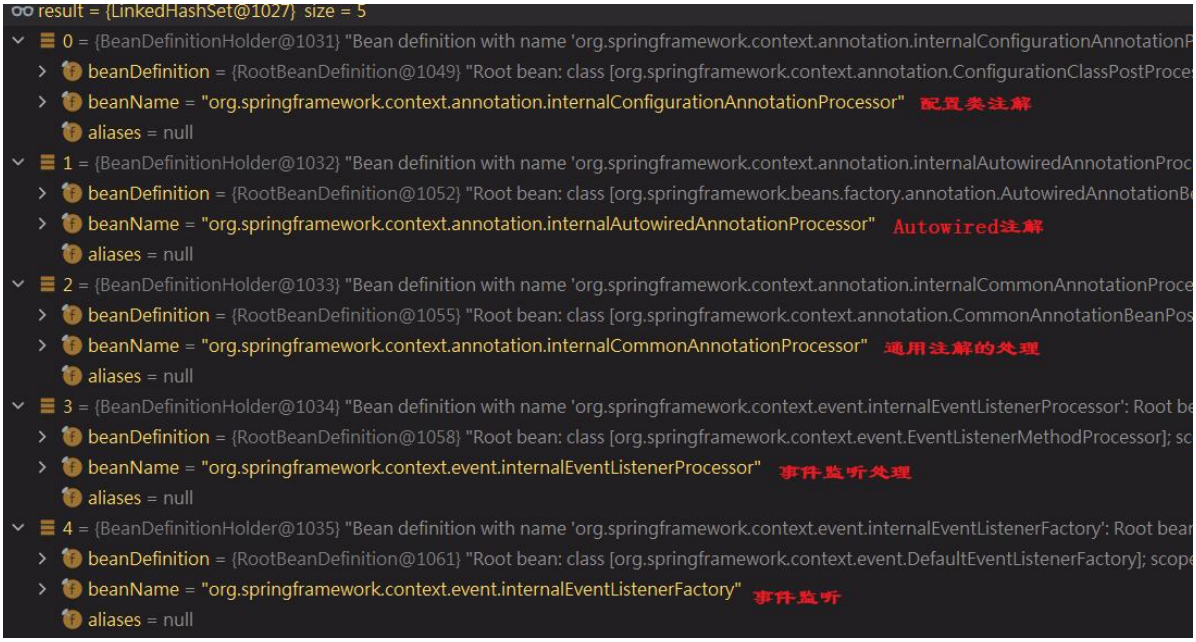
```
//AnnotationConfigApplicationContext类
public AnnotationConfigApplicationContext() {
    //AnnotatedBeanDefinitionReader  reader 带注释的 Bean 定义阅读器
    this.reader = new AnnotatedBeanDefinitionReader(this); //传入当前类
AnnotationConfigApplicationContext
    //ClassPathBeanDefinitionScanner scanner 类路径 Bean 定义扫描器
    this.scanner = new ClassPathBeanDefinitionScanner(this);
}
```

- **this.reader = new AnnotatedBeanDefinitionReader(this);**

```
public AnnotatedBeanDefinitionReader(BeanDefinitionRegistry registry) {
   this(registry, getOrCreateEnvironment(registry));
}

getOrCreateEnvironment(registry) //创建一个新的标准环境 拿到系统的一些环境信息

//首先对AnnotatedBeanDefinitionReader成员变量初始化 ： BeanNameGenerator，
ScopeMetadataResolver对象
public AnnotatedBeanDefinitionReader(BeanDefinitionRegistry registry,
Environment environment) {
    //断言（作用不合法抛出异常）
    Assert.notNull(registry, "BeanDefinitionRegistry must not be null");
    Assert.notNull(environment, "Environment must not be null");
    //将AnnotationConfigApplicationContext赋值给成员变量
    this.registry = registry;
    //根据registr与环境变量创建一个 *条件评估器*  判断是否含有@Conditional条件注解
    this.conditionEvaluator = new ConditionEvaluator(registry, environment,
null);
    //注册注解配置处理器  含有5个BeanDefinition()
    AnnotationConfigUtils.registerAnnotationConfigProcessors(this.registry);
}
```



- **this.scanner = new ClassPathBeanDefinitionScanner(this);**

  放入一个@Component对这个注解进行扫描

```
public ClassPathBeanDefinitionScanner(BeanDefinitionRegistry registry) {
   this(registry, true);
}
public ClassPathBeanDefinitionScanner(BeanDefinitionRegistry registry, boolean
useDefaultFilters) {
    this(registry, useDefaultFilters, getOrCreateEnvironment(registry)); //获取系
统环境变量
}
public ClassPathBeanDefinitionScanner(BeanDefinitionRegistry registry, boolean
useDefaultFilters,
                                      Environment environment) {

    this(registry, useDefaultFilters, environment,
         (registry instanceof ResourceLoader ? (ResourceLoader) registry :
null));
}

public ClassPathBeanDefinitionScanner(BeanDefinitionRegistry registry, boolean
useDefaultFilters,
                                      Environment environment, @Nullable
ResourceLoader resourceLoader) {
    //断言
    Assert.notNull(registry, "BeanDefinitionRegistry must not be null");
    this.registry = registry; //注释配置应用程序上下文
AnnotationConfigApplicationContext

    if (useDefaultFilters) {
        registerDefaultFilters();/* 默认filter会将@Component注解类放入 若类含有
@Component会扫描到注解
                                    类路径扫描候选组件提供者
                                   */
    }
    setEnvironment(environment);
    setResourceLoader(resourceLoader);
}
```

1.2、register(componentClasses);

- 把componentClasses变成bean的描述：beanDefinition
- 使用BeanDefinitionHolder对beanDefinition与beanName包装
- 将BeanDefinitionHolder中刚放入的BeanDefinition注册到beanDefinitionMap中
- **核心就是将我们自己写的配置类放入到beanDefinitionMap中**

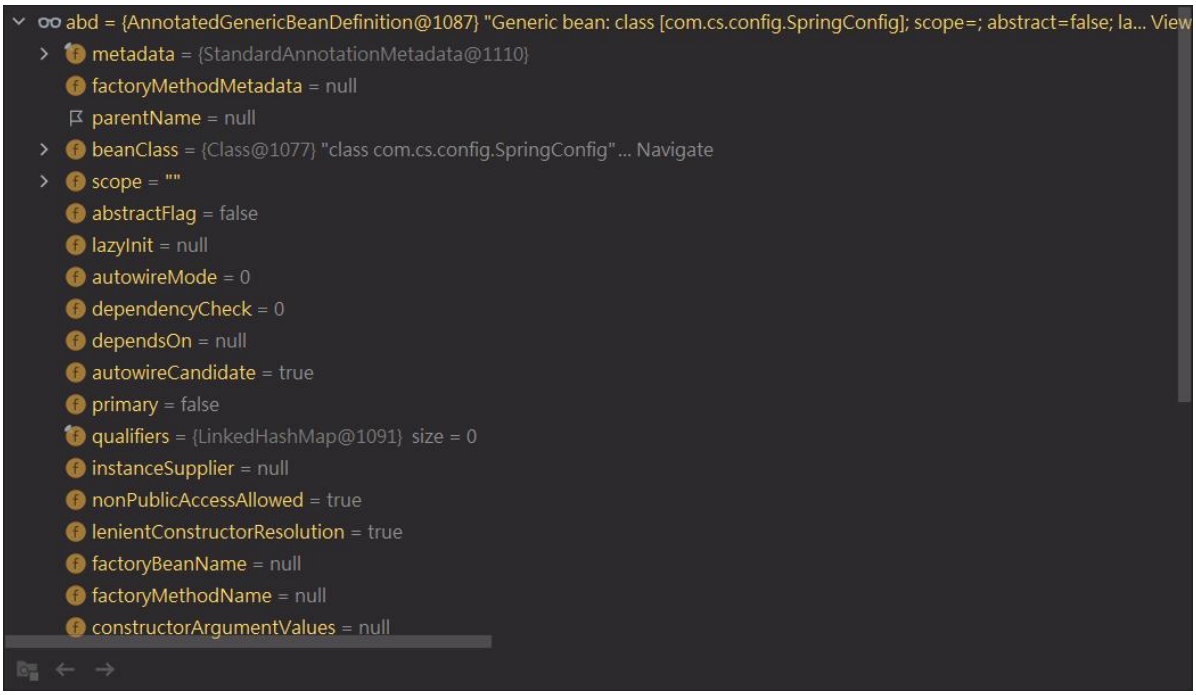
```
//注册一个或多个要处理的组件类。 <p>请注意，必须调用 {@link refresh()} 才能使上下文完全处理新类。
//AnnotationConfigApplicationContext类
public void register(Class<?>... componentClasses) {  //
    Assert.notEmpty(componentClasses, "At least one component class must be specified");
    this.reader.register(componentClasses);  //componentClasses  配置类.class
    //reader是AnnotatedBeanDefinitionReader在this()中创建
}
//AnnotatedBeanDefinitionReader类 遍历循环看含有都多少配置类 注册一个或多个要处理的组件类。
public void register(Class<?>... componentClasses) {
    for (Class<?> componentClass : componentClasses) {
        registerBean(componentClass);
    }
}
//从给定的 bean 类注册一个 bean，从类声明的注释中派生其元数据
public void registerBean(Class<?> beanClass) {
    doRegisterBean(beanClass, null, null, null, null);
}

private <T> void doRegisterBean(Class<T> beanClass, @Nullable String name,
                                @Nullable Class<? extends Annotation>[] qualifiers, @Nullable Supplier<T> supplier,
                                @Nullable BeanDefinitionCustomizer[] customizers) {
    //把componentClasses变成bean的描述：beanDefinition 含有bean的class以及他的元注解
    AnnotatedGenericBeanDefinition abd = new AnnotatedGenericBeanDefinition(beanClass);
    if (this.conditionEvaluator.shouldSkip(abd.getMetadata())) {//判断  其是否有条件注解
        return;
    }
    //设置其数据 scopedProxyMode 决定使用
    abd.setInstanceSupplier(supplier);
    //解析注解Bean定义的作用域，若@Scope("prototype")，则Bean为原型类型；
    //若@Scope("singleton")，则Bean为单态类型
    ScopeMetadata scopeMetadata = this.scopeMetadataResolver.resolveScopeMetadata(abd);
    abd.setScope(scopeMetadata.getScopeName());
    //根据信息创建bean的名字  registry = AnnotationConfigApplicationContext
    //beanName='springConfig'
    String beanName = (name != null ? name : this.beanNameGenerator.generateBeanName(abd, this.registry));
    //是否有@Lazy @Primary等注解
    AnnotationConfigUtils.processCommonDefinitionAnnotations(abd);
    if (qualifiers != null) {
        for (Class<? extends Annotation> qualifier : qualifiers) {
```

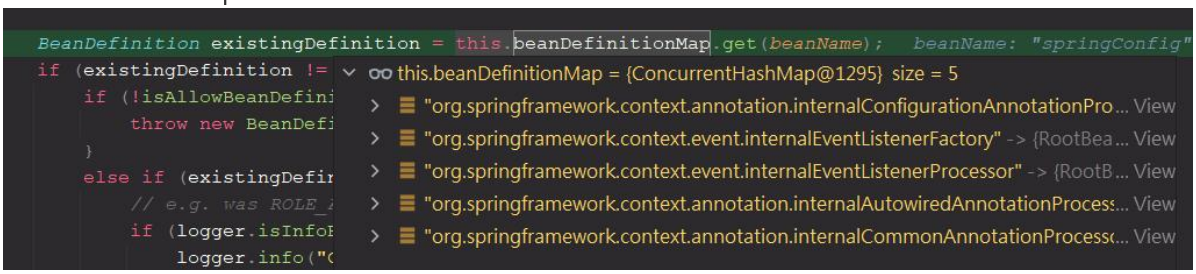
```
            if (Primary.class == qualifier) {
                abd.setPrimary(true);
            }
            else if (Lazy.class == qualifier) {
                abd.setLazyInit(true);
            }
            else {
                abd.addQualifier(new AutowireCandidateQualifier(qualifier));
            }
        }
    }
    if (customizers != null) {
        for (BeanDefinitionCustomizer customizer : customizers) {
            customizer.customize(abd);
        }
    }
    //使用BeanDefinitionHolder对beanDefinition与beanName包装
    BeanDefinitionHolder definitionHolder = new BeanDefinitionHolder(abd,
beanName);
    definitionHolder = AnnotationConfigUtils.applyScopedProxyMode(scopeMetadata,
definitionHolder, this.registry);
    //注册（BeanDefinitionHolder中刚放入的BeanDefinition注册到beanDefinitionMap中）
    BeanDefinitionReaderUtils.registerBeanDefinition(definitionHolder,
this.registry);
}

//注册 [registerBeanDefinition]方法：
    String beanName = definitionHolder.getBeanName();
    registry.registerBeanDefinition(beanName,
definitionHolder.getBeanDefinition());
//核心：
//registerBeanDefinition方法中出现的beanDefinitionMap就是spring的5个bean
BeanDefinition existingDefinition = this.beanDefinitionMap.get(beanName);
//先进行判断是否含有若无将其放入到beanDefinitionMap
this.beanDefinitionMap.put(beanName, beanDefinition);
//名字
this.beanDefinitionNames.add(beanName);
removeManualSingletonName(beanName);
```

abd:



beanDefinitionMap:



1.3、refresh(); 核心

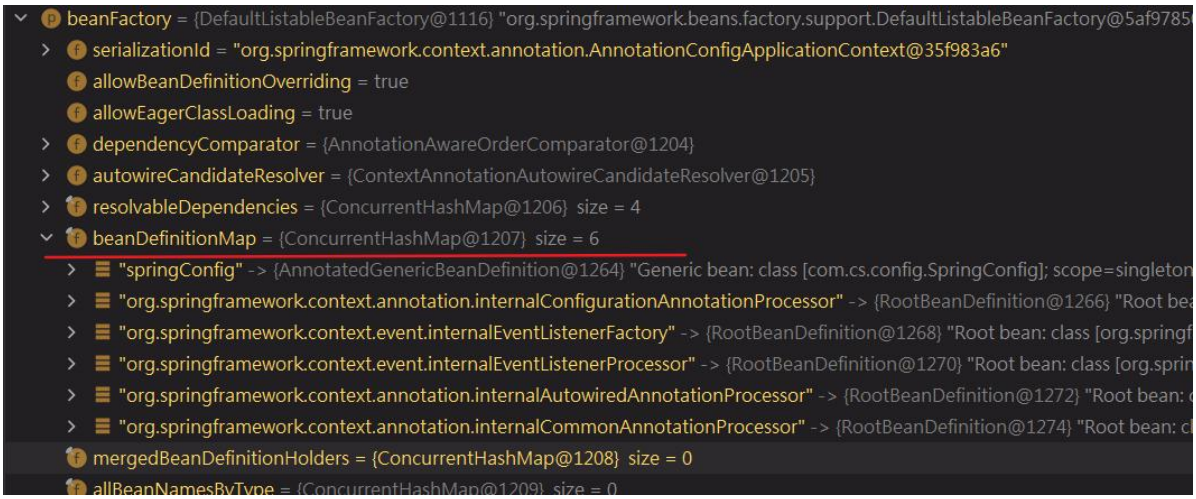
刷新spring容器的12个步骤

- 扫描项目中的bean（@Service、@Compment....注解的bean）得到BeanDefinition，然后放入到BeanDefinitionMap
- 把BeanDefinitionMap取出依次创建所对应的对象

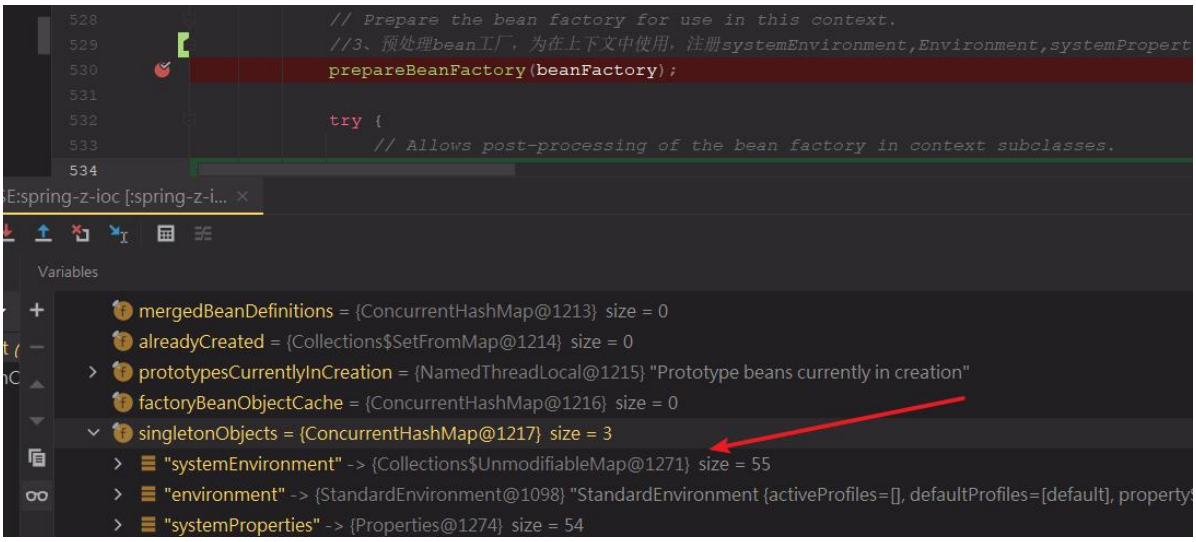
1-4：前4步

```
//线程同步
synchronized (this.startupShutdownMonitor) {
   // 1、Prepare this context for refreshing. 准备对上下文进行刷新
   prepareRefresh();

   // TODO Tell the subclass to refresh the internal bean factory.
   //2、告诉子类去刷新内部的bean factory,获得刷新的bean factory，最终得到的是
DefaultListableBeanFactory,并且加载
   //如果是xml方式开发，此步骤重要，若是注解方式开发没什么操作
   ConfigurableListableBeanFactory beanFactory = obtainFreshBeanFactory();
    {   //会获取beanFactory,
        return getBeanFactory(); //继承当前类 模板方法模式
    }
```




```
 // Prepare the bean factory for use in this context.
   //3、预处理bean工厂，为在上下文中使用，注册
systemEnvironment,Environment,systemProperties几个bean对象（spring自己的对象）
   prepareBeanFactory(beanFactory);
```




```
//4、什么都没有做 Allows post-processing of the bean factory in context subclasses.
postProcessBeanFactory(beanFactory);
```

5.核心： 扫描得到bean定义

注解开发的时候，对包扫描得到的bean定义在此步骤完成的，底层就是扫描注解得到bean定义，然后放入到beanFactory

激活各种BeanFactory处理器，如果BeanFactory没有注册任何beanFactoryPostProcessor,此处相当于此处相当于不做操作

```
invokeBeanFactoryPostProcessors(beanFactory);
```

ApplicationContext—->BeanFactory (BeanFactoryPostProcessor)

```
/**
*  TODO 对所有的BeanDefinitionRegistryPostProcessor 手动注册
BeanFactoryPostProcessor
*        以及通过配置文件方式的BeanFactoryPostProcessor按照PriorityOrderd、Orderd、no
orderd三种方式分开处理、调用
*/
invokeBeanFactoryPostProcessors{

 PostProcessorRegistrationDelegate.invokeBeanFactoryPostProcessors(beanFactory,
getBeanFactoryPostProcessors());
}
```

5.1、对所有的beanFactoryPostProcessors做处理

BeanFactoryPostProcessors有三种情况：

1、我们手动注册

2、Spring扫描出来的

3、Spring自定义的

什么是手动注册的?

就是我们手动调用AnnotationConfigApplicationContext.addBeanFactoryPostProcessor();这个方法添加的。

什么是Spring扫描出来的?

我们自己实现了BeanFactoryPostProcessor接口的类可以加@Companent，也可以不加，如果加了那么就属于是Spring扫描出来的。

什么是Spring自定义的?

在Spring内容也有其实现类BeanFactoryPostProcessor接口的类，它会自己去获取出来，我们不用管。

```
for (BeanFactoryPostProcessor postProcessor : beanFactoryPostProcessors) {
    if (postProcessor instanceof BeanDefinitionRegistryPostProcessor) {
        BeanDefinitionRegistryPostProcessor registryProcessor =
                            (BeanDefinitionRegistryPostProcessor) postProcessor;
        registryProcessor.postProcessBeanDefinitionRegistry(registry);
        registryProcessors.add(registryProcessor);
        }
    else {
        regularPostProcessors.add(postProcessor);
    }
}
```

5.2、扫描配置类获取beanDefintion

regularPostProcessors	用于存放普通的BeanFactoryPostProcessor
registryProcessors	BeanDefinitionRegistryPostProcessor
beanFactoryPostProcessors	当前容器的所有Processors<
processedBeans	存放BeanName
currentRegistryProcessors	存放含有PriorityOrdered注解的BeanDefinitionRegistryPostProcessor

5.2.1、 获取所有的BeanDefinitionRegistryPostProcessor

（Bean定义注册表后处理器，可以修改bean定义的一些数据）

```
String[] postProcessorNames =

beanFactory.getBeanNamesForType(BeanDefinitionRegistryPostProcessor.class, true,
false);
for (String ppName : postProcessorNames) {
    if (beanFactory.isTypeMatch(ppName, PriorityOrdered.class)) {
        currentRegistryProcessors.add(beanFactory.getBean(ppName,
 BeanDefinitionRegistryPostProcessor.class));//将 PostProcessor添加到集合中
        processedBeans.add(ppName);
    }
}
//优先级要求      PriorityOrdered
//postProcessorNames =  内部配置注释处理器
//
org.springframework.context.annotation.internalConfigurationAnnotationProcessor
```

5.2.2、*注册bean定义** (根据获取的currentRegistryProcessors中的内部配置注释处理器)

```
sortPostProcessors(currentRegistryProcessors, beanFactory); //对postprocessor排序
registryProcessors.addAll(currentRegistryProcessors);
invokeBeanDefinitionRegistryPostProcessors(currentRegistryProcessors, registry);
//TODO 调用postProcessor 可以对bean进行更改(判断获取到配置类) （配置类中的bean变为
Definition并放入beanFactory的map中）
currentRegistryProcessors.clear();
```

- 循环遍历PostProcessor
- 注册beanDefinitions： eprocessConfigBeanDefinitions(registry); registry==beanFactory
- 1、获取beanFactory中的所有的bean定义,判断是否有含有 @Configuration 注解的bean定义筛选出来 符合条件的候选者bean定义

  获取配置类，根据配置注解中的proxyBeanMethods属性值（默认是ture）会对其配置类定义中放入一个full属性值

```
for (String beanName : candidateNames) {
    BeanDefinition beanDef = registry.getBeanDefinition(beanName);
    if
(beanDef.getAttribute(ConfigurationClassUtils.CONFIGURATION_CLASS_ATTRIBUTE)
!= null) {
        if (logger.isDebugEnabled()) {
         logger.debug("Bean definition has already been processed as a
configuration class: " + beanDef);
        }
        } //含有 @Configuration 注解的bean定义筛选出来 符合条件的候选者bean定义
    else if
(ConfigurationClassUtils.checkConfigurationClassCandidate(beanDef,
this.metadataReaderFactory)) {
        configCandidates.add(new BeanDefinitionHolder(beanDef, beanName));
    }
}
```

```
public static boolean checkConfigurationClassCandidate(
    BeanDefinition beanDef, MetadataReaderFactory metadataReaderFactory) {

    String className = beanDef.getBeanClassName();
    if (className == null || beanDef.getFactoryMethodName() != null) {
        return false;
    }

    AnnotationMetadata metadata;
    if (beanDef instanceof AnnotatedBeanDefinition &&
        className.equals(((AnnotatedBeanDefinition)
beanDef).getMetadata().getClassName())) {
        // Can reuse the pre-parsed metadata from the given
BeanDefinition...
        metadata = ((AnnotatedBeanDefinition) beanDef).getMetadata();
    }
    else if (beanDef instanceof AbstractBeanDefinition &&
((AbstractBeanDefinition) beanDef).hasBeanClass()) {
        // Check already loaded Class if present...
        // since we possibly can't even load the class file for this Class.
        Class<?> beanClass = ((AbstractBeanDefinition)
beanDef).getBeanClass();
        if (BeanFactoryPostProcessor.class.isAssignableFrom(beanClass) ||
            BeanPostProcessor.class.isAssignableFrom(beanClass) ||
            AopInfrastructureBean.class.isAssignableFrom(beanClass) ||
            EventListenerFactory.class.isAssignableFrom(beanClass)) {
            return false;
        }
        metadata = AnnotationMetadata.introspect(beanClass);
    }
    else {
        try {
            MetadataReader metadataReader =
metadataReaderFactory.getMetadataReader(className);
            metadata = metadataReader.getAnnotationMetadata();
        }
        catch (IOException ex) {
            if (logger.isDebugEnabled()) {
```

```
                logger.debug("Could not find class file for introspecting
configuration annotations: " +
                             className, ex);
            }
            return false;
        }
    }
    //配置类 上的@Configuration
    Map<String, Object> config =
metadata.getAnnotationAttributes(Configuration.class.getName());
    if (config != null &&
!Boolean.FALSE.equals(config.get("proxyBeanMethods"))) { //todo
@Configuration 默认值是true
        beanDef.setAttribute(CONFIGURATION_CLASS_ATTRIBUTE,
CONFIGURATION_CLASS_FULL); //full在下面 配置类中对beanFactory做增强使用
    }
    else if (config != null || isConfigurationCandidate(metadata)) {
        beanDef.setAttribute(CONFIGURATION_CLASS_ATTRIBUTE,
CONFIGURATION_CLASS_LITE);
    }
    else {
        return false;
    }

    // It's a full or lite configuration candidate... Let's determine the
order value, if any. 类上的@Order 注解排序
    Integer order = getOrder(metadata);
    if (order != null) {
        beanDef.setAttribute(ORDER_ATTRIBUTE, order);
    }

    return true;
}
```

- 创建配置类解析器 解析每一个带有@Configuration注解的类（beanFactory传入）

```
ConfigurationClassParser parser = new ConfigurationClassParser(
      this.metadataReaderFactory, this.problemReporter, this.environment,
      this.resourceLoader, this.componentScanBeanNameGenerator, registry);
```

- 1、对配置类进行处理

```
parser.parse(candidates);
parser.validate();
```

  - ```
    public void parse(Set<BeanDefinitionHolder> configCandidates) {
        for (BeanDefinitionHolder holder : configCandidates) {
            BeanDefinition bd = holder.getBeanDefinition();
            try {
                if (bd instanceof AnnotatedBeanDefinition) {  //将配置类中的
    bean元数据信息放入到map集合
                    parse(((AnnotatedBeanDefinition) bd).getMetadata(),
    holder.getBeanName());
                }
                else if (bd instanceof AbstractBeanDefinition &&
    ((AbstractBeanDefinition) bd).hasBeanClass()) {
    ```
    ```

```
                parse(((AbstractBeanDefinition) bd).getBeanClass(),
holder.getBeanName());
            }
            else {
                parse(bd.getBeanClassName(), holder.getBeanName());
            }
        }
        catch (BeanDefinitionStoreException ex) {
            throw ex;
        }
        catch (Throwable ex) {
            throw new BeanDefinitionStoreException(
                "Failed to parse configuration class [" +
bd.getBeanClassName() + "]", ex);
        }
    }
    //内部类 TODO springboot自动配置（@Import）
    this.deferredImportSelectorHandler.process();
}
```

- 处理配置类

```
protected final void parse(AnnotationMetadata metadata, String beanName)
throws IOException {
   processConfigurationClass(new ConfigurationClass(metadata, beanName),
DEFAULT_EXCLUSION_FILTER);
}
```

- 首先判断是否有条件处理

```
protected void processConfigurationClass(ConfigurationClass configClass,
Predicate<String> filter) throws IOException {
    // 通过条件计算器判断是否跳过解析*
    // 通过@Conditional({})来进行*
    // 如果没有被@Conditional修饰，或者条件符合@Conditional的话，就跳过。反之，
就跳过
    if (this.conditionEvaluator.shouldSkip(configClass.getMetadata(),
ConfigurationPhase.PARSE_CONFIGURATION)) {
        return;
    }

    ConfigurationClass existingClass =
this.configurationClasses.get(configClass);
    if (existingClass != null) {
        if (configClass.isImported()) {
            if (existingClass.isImported()) {
                existingClass.mergeImportedBy(configClass);
            }
            // Otherwise ignore new imported config class; existing non-
imported class overrides it.
            return;
        }
        else {
            // Explicit bean definition found, probably replacing an
import.
            // Let's remove the old one and go with the new one.
```

```
            this.configurationClasses.remove(configClass);

 this.knownSuperclasses.values().removeIf(configClass::equals);
        }
    }

    // 处理配置类，由于配置类可能存在父类(若父类的全类名是以java开头的，则除外)，所有需要将configClass变成sourceClass去解析，然后返回sourceClass的父类。
    // 如果此时父类为空，则不会进行while循环去解析，如果父类不为空，则会循环的去解析父类
    // SourceClass的意义：简单的包装类，目的是为了以统一的方式去处理带有注解的类，不管这些类是如何加载的
    // 如果无法理解，可以把它当做一个黑盒，不会影响看spring源码的主流程
configClass ==> ConfigurationClass
    SourceClass sourceClass = asSourceClass(configClass, filter);
    do { //处理配置类
        sourceClass = doProcessConfigurationClass(configClass, sourceClass, filter);
    }
    while (sourceClass != null);

    this.configurationClasses.put(configClass, configClass); //放入map集合
}
```

- 1、处理配置类 sourceClass。如果添加了@ComponentScan注解进行包扫描，会将BeanDefinition放入map中。

```
protected final SourceClass doProcessConfigurationClass(
    ConfigurationClass configClass, SourceClass sourceClass,
Predicate<String> filter)
    throws IOException {
    //是否是 @Component 注解
    if
(configClass.getMetadata().isAnnotated(Component.class.getName())) {
        // 递归处理内部类，因为内部类也是一个配置类，配置类上有@configuration注解，该注解继承@Component，if判断为true，调用processMemberClasses方法，递归解析配置类中的内部类
        processMemberClasses(configClass, sourceClass, filter); //什么也没干
    }

    // Process any @PropertySource annotations
    // 【@PropertySource】  如果配置类上加了@PropertySource注解，那么就解析加载properties文件，并将属性添加到spring上下文中
    for (AnnotationAttributes propertySource :
AnnotationConfigUtils.attributesForRepeatable(
        sourceClass.getMetadata(), PropertySources.class,
        org.springframework.context.annotation.PropertySource.class)) {
        if (this.environment instanceof ConfigurableEnvironment) {
            // 进去查看添加配置文件到上下文中
            processPropertySource(propertySource);
        }
        else {
            logger.info("Ignoring @PropertySource annotation on [" +
sourceClass.getMetadata().getClassName() +
```

```
                        "]. Reason: Environment must implement
ConfigurableEnvironment");
        }
    }

    // Process any @ComponentScan annotations
    // 【@ComponentScan】处理@ComponentScan或者@ComponentScans注解，并将扫描
包下的所有bean转换成填充后的ConfigurationClass
    // 此处就是将自定义的bean加载到IOC容器，因为扫描到的类可能也添加了
@ComponentScan和@ComponentScans注解，因此需要进行递归解析
    Set<AnnotationAttributes> componentScans =
AnnotationConfigUtils.attributesForRepeatable(
        sourceClass.getMetadata(), ComponentScans.class,
ComponentScan.class);
    if (!componentScans.isEmpty() &&
        !this.conditionEvaluator.shouldSkip(sourceClass.getMetadata(),
ConfigurationPhase.REGISTER_BEAN)) {
        // The config class is annotated with @ComponentScan -> perform
the scan immediately
        // 解析@ComponentScan和@ComponentScans配置的扫描的包所包含的类
        // 比如 basePackages = com.mashibing, 那么在这一步会扫描出这个包及子包
下的class，然后将其解析成BeanDefinition
        // (BeanDefinition可以理解为等价于BeanDefinitionHolder)
        for (AnnotationAttributes componentScan : componentScans) {
            // The config class is annotated with @ComponentScan ->
perform the scan immediately
            Set<BeanDefinitionHolder> scannedBeanDefinitions =
                this.componentScanParser.parse(componentScan,
sourceClass.getMetadata().getClassName());
            // Check the set of scanned definitions for any further
config classes and parse recursively if needed
            // 通过上一步扫描包com.mashibing，有可能扫描出来的bean中可能也添加了
ComponentScan或者ComponentScans注解.
            //所以这里需要循环遍历一次，进行递归(parse)，继续解析，直到解析出的类上
没有ComponentScan和ComponentScans
            for (BeanDefinitionHolder holder : scannedBeanDefinitions) {
                BeanDefinition bdCand =
holder.getBeanDefinition().getOriginatingBeanDefinition();
                if (bdCand == null) {
                    bdCand = holder.getBeanDefinition();
                }
                // 判断是否是一个配置类，并设置full或lite属性
                if
(ConfigurationClassUtils.checkConfigurationClassCandidate(bdCand,
this.metadataReaderFactory)) {
                    // 通过递归方法进行解析
                    parse(bdCand.getBeanClassName(),
holder.getBeanName());
                }
            }
        }
    }

    //处理Improt注解
    processImports(configClass, sourceClass, getImports(sourceClass),
filter, true);

    // Process any @ImportResource annotations
```

```
    AnnotationAttributes importResource =
        AnnotationConfigUtils.attributesFor(sourceClass.getMetadata(),
ImportResource.class);
    if (importResource != null) {
        String[] resources = importResource.getStringArray("locations");
        Class<? extends BeanDefinitionReader> readerClass =
importResource.getClass("reader");
        for (String resource : resources) {
            String resolvedResource =
this.environment.resolveRequiredPlaceholders(resource);
            configClass.addImportedResource(resolvedResource,
readerClass);
        }
    }

    //TODO 处理@Bean注解  configClass == springConfig
    Set<MethodMetadata> beanMethods =
retrieveBeanMethodMetadata(sourceClass);
    for (MethodMetadata methodMetadata : beanMethods) {
        configClass.addBeanMethod(new BeanMethod(methodMetadata,
configClass)); //将bean方法的元数据放入configClass(有类的元数据)
    }

    // 默认方法
    processInterfaces(configClass, sourceClass);

    // Process superclass, if any 继承
    if (sourceClass.getMetadata().hasSuperClass()) {
        String superclass =
sourceClass.getMetadata().getSuperClassName();
        if (superclass != null && !superclass.startsWith("java") &&
            !this.knownSuperclasses.containsKey(superclass)) {
            this.knownSuperclasses.put(superclass, configClass);
            // Superclass found, return its annotation metadata and
recurse
            return sourceClass.getSuperClass();
        }
    }

    // No superclass -> processing is complete
    return null;
}
```

- 处理@Bean注解

  从配置类中获取添加@Bean注解的方法放入configClass

- 2、放入map集合 （在使用aop中会放入一个beanDefinition处理代理）

```
// 配置类Bean定义阅读器 Read the model and create bean definitions based on
its content
if (this.reader == null) {
    this.reader = new ConfigurationClassBeanDefinitionReader(
        registry, this.sourceExtractor, this.resourceLoader,
this.environment,
        this.importBeanNameGenerator, parser.getImportRegistry());
}
this.reader.loadBeanDefinitions(configClasses); //TODO 将bean定义放入
beanFactory的map（加载bean的定义，会处理@Bean方法上的所有注解）
alreadyParsed.addAll(configClasses);
```

- ```
  public void loadBeanDefinitions(Set<ConfigurationClass>
  configurationModel) {
      TrackedConditionEvaluator trackedConditionEvaluator = new
  TrackedConditionEvaluator();
      for (ConfigurationClass configClass : configurationModel) {
          loadBeanDefinitionsForConfigurationClass(configClass,
  trackedConditionEvaluator);
      }
  }
  ```

- ```
  private void loadBeanDefinitionsForConfigurationClass(
      ConfigurationClass configClass, TrackedConditionEvaluator
  trackedConditionEvaluator) {

      if (trackedConditionEvaluator.shouldSkip(configClass)) {
          String beanName = configClass.getBeanName();
          if (StringUtils.hasLength(beanName) &&
  this.registry.containsBeanDefinition(beanName)) {
              this.registry.removeBeanDefinition(beanName);
          }

       this.importRegistry.removeImportingClass(configClass.getMetadata().
  getClassName());
          return;
      }

      if (configClass.isImported()) {

       registerBeanDefinitionForImportedConfigurationClass(configClass);
      } //TODO 加载@Bean注解方法的所定义的beanDefinition
      for (BeanMethod beanMethod : configClass.getBeanMethods()) {
          loadBeanDefinitionsForBeanMethod(beanMethod);
      }
      //@ImportResource 注解

       loadBeanDefinitionsFromImportedResources(configClass.getImportedRes
  ources());

       loadBeanDefinitionsFromRegistrars(configClass.getImportBeanDefiniti
  onRegistrars());
  }
  ```

- ```
  //对当前@Bean修饰的方法上的注解的
  ```
  ```

```
private void loadBeanDefinitionsForBeanMethod(BeanMethod beanMethod)
{
    ConfigurationClass configClass =
beanMethod.getConfigurationClass();
    MethodMetadata metadata = beanMethod.getMetadata();
    String methodName = metadata.getMethodName();

    // Do we need to mark the bean as skipped by its condition?
    if (this.conditionEvaluator.shouldSkip(metadata,
ConfigurationPhase.REGISTER_BEAN)) {
        configClass.skippedBeanMethods.add(methodName);
        return;
    }
    if (configClass.skippedBeanMethods.contains(methodName)) {
        return;
    }
    //获取@Bean注解属性
    AnnotationAttributes bean =
AnnotationConfigUtils.attributesFor(metadata, Bean.class);
    Assert.state(bean != null, "No @Bean annotation attributes");

    // Consider name and any aliases 注解名字
    List<String> names = new ArrayList<>
(Arrays.asList(bean.getStringArray("name")));
    String beanName = (!names.isEmpty() ? names.remove(0) :
methodName);

    // Register aliases even when overridden
    for (String alias : names) {
        this.registry.registerAlias(beanName, alias);
    }

    // Has this effectively been overridden before (e.g. via XML)?
    if (isOverriddenByExistingDefinition(beanMethod, beanName)) {
        if
(beanName.equals(beanMethod.getConfigurationClass().getBeanName()))
{
            throw new
BeanDefinitionStoreException(beanMethod.getConfigurationClass().getR
esource().getDescription(),
                                                    beanName, "Bean
name derived from @Bean method '" +
beanMethod.getMetadata().getMethodName() +
                                                    "' clashes with
bean name for containing configuration class; please make those
names unique!");
        }
        return;
    }
    //创建一个beandefinition
    ConfigurationClassBeanDefinition beanDef = new
ConfigurationClassBeanDefinition(configClass, metadata, beanName);
    beanDef.setSource(this.sourceExtractor.extractSource(metadata,
configClass.getResource()));

    if (metadata.isStatic()) {
        // static @Bean method
```

```
        if (configClass.getMetadata() instanceof
StandardAnnotationMetadata) {
            beanDef.setBeanClass(((StandardAnnotationMetadata)
configClass.getMetadata()).getIntrospectedClass());
        }
        else {

 beanDef.setBeanClassName(configClass.getMetadata().getClassName());
        }
        beanDef.setUniqueFactoryMethodName(methodName);
    }
    else {
        // instance @Bean method
        beanDef.setFactoryBeanName(configClass.getBeanName());
        beanDef.setUniqueFactoryMethodName(methodName);
    }

    if (metadata instanceof StandardMethodMetadata) {
        beanDef.setResolvedFactoryMethod(((StandardMethodMetadata)
metadata).getIntrospectedMethod());
    }


 beanDef.setAutowireMode(AbstractBeanDefinition.AUTOWIRE_CONSTRUCTOR
);

 beanDef.setAttribute(org.springframework.beans.factory.annotation.R
equiredAnnotationBeanPostProcessor.
                        SKIP_REQUIRED_CHECK_ATTRIBUTE,
Boolean.TRUE);
    //通用注解

 AnnotationConfigUtils.processCommonDefinitionAnnotations(beanDef,
metadata);
    //bean中的属性
    Autowire autowire = bean.getEnum("autowire");
    if (autowire.isAutowire()) {
        beanDef.setAutowireMode(autowire.value());
    }

    boolean autowireCandidate =
bean.getBoolean("autowireCandidate");
    if (!autowireCandidate) {
        beanDef.setAutowireCandidate(false);
    }

    String initMethodName = bean.getString("initMethod");
    if (StringUtils.hasText(initMethodName)) {
        beanDef.setInitMethodName(initMethodName);
    }

    String destroyMethodName = bean.getString("destroyMethod");
    beanDef.setDestroyMethodName(destroyMethodName);

    // Consider scoping @Scope 注解
    ScopedProxyMode proxyMode = ScopedProxyMode.NO;
    AnnotationAttributes attributes =
AnnotationConfigUtils.attributesFor(metadata, Scope.class);
```

```
    if (attributes != null) {
        beanDef.setScope(attributes.getString("value"));
        proxyMode = attributes.getEnum("proxyMode");
        if (proxyMode == ScopedProxyMode.DEFAULT) {
            proxyMode = ScopedProxyMode.NO;
        }
    }

    // Replace the original bean definition with the target one, if
necessary
    BeanDefinition beanDefToRegister = beanDef;
    if (proxyMode != ScopedProxyMode.NO) {
        BeanDefinitionHolder proxyDef =
ScopedProxyCreator.createScopedProxy(
            new BeanDefinitionHolder(beanDef, beanName),
this.registry,
            proxyMode == ScopedProxyMode.TARGET_CLASS);
        beanDefToRegister = new ConfigurationClassBeanDefinition(
            (RootBeanDefinition) proxyDef.getBeanDefinition(),
configClass, metadata, beanName);
    }

    if (logger.isTraceEnabled()) {
        logger.trace(String.format("Registering bean definition for
@Bean method %s.%s()",

configClass.getMetadata().getClassName(), beanName));
    }
    //TODO 将bean放入beanFactory 的 map
    this.registry.registerBeanDefinition(beanName,
beanDefToRegister);
}
```

- 放入beanDefinitionMap中

```
@Override
public void registerBeanDefinition(String beanName, BeanDefinition
beanDefinition)
    throws BeanDefinitionStoreException {

    Assert.hasText(beanName, "Bean name must not be empty");
    Assert.notNull(beanDefinition, "BeanDefinition must not be
null");

    if (beanDefinition instanceof AbstractBeanDefinition) {
        try {//是否合法的
            ((AbstractBeanDefinition) beanDefinition).validate();
        }
        catch (BeanDefinitionValidationException ex) {
            throw new
BeanDefinitionStoreException(beanDefinition.getResourceDescription()
, beanName,
                                                   "Validation of
bean definition failed", ex);
        }
    }
    //查看是否已有此beanDefinition
```

```
    BeanDefinition existingDefinition =
this.beanDefinitionMap.get(beanName);
    if (existingDefinition != null) {
        if (!isAllowBeanDefinitionOverriding()) {
            throw new BeanDefinitionOverrideException(beanName,
beanDefinition, existingDefinition);
        }
        else if (existingDefinition.getRole() <
beanDefinition.getRole()) {
            // e.g. was ROLE_APPLICATION, now overriding with
ROLE_SUPPORT or ROLE_INFRASTRUCTURE
            if (logger.isInfoEnabled()) {
                logger.info("Overriding user-defined bean definition
for bean '" + beanName +
                            "' with a framework-generated bean
definition: replacing [" +
                            existingDefinition + "] with [" +
beanDefinition + "]");
            }
        }
        else if (!beanDefinition.equals(existingDefinition)) {
            if (logger.isDebugEnabled()) {
                logger.debug("Overriding bean definition for bean '"
+ beanName +
                             "' with a different definition:
replacing [" + existingDefinition +
                             "] with [" + beanDefinition + "]");
            }
        }
        else {
            if (logger.isTraceEnabled()) {
                logger.trace("Overriding bean definition for bean '"
+ beanName +
                             "' with an equivalent definition:
replacing [" + existingDefinition +
                             "] with [" + beanDefinition + "]");
            }
        }//将bean描述存放到map中
        this.beanDefinitionMap.put(beanName, beanDefinition);
    }
    else {
        if (hasBeanCreationStarted()) {  //将bean描述存放到map中
            // Cannot modify startup-time collection elements
anymore (for stable iteration)
            synchronized (this.beanDefinitionMap) {
                this.beanDefinitionMap.put(beanName,
beanDefinition);
                List<String> updatedDefinitions = new ArrayList<>
(this.beanDefinitionNames.size() + 1);
                updatedDefinitions.addAll(this.beanDefinitionNames);
                updatedDefinitions.add(beanName);
                this.beanDefinitionNames = updatedDefinitions;
                removeManualSingletonName(beanName);
            }
        }
        else {
            // Still in startup registration phase
            this.beanDefinitionMap.put(beanName, beanDefinition);
```

```
            this.beanDefinitionNames.add(beanName);
            removeManualSingletonName(beanName);
        }
        this.frozenBeanDefinitionNames = null;
    }

    if (existingDefinition != null || containsSingleton(beanName)) {
        resetBeanDefinition(beanName);
    }
    else if (isConfigurationFrozen()) {
        clearByTypeCache();
    }
}
```

5.2.3、处理其他BeanDefinitionRegistryPostProcessor

1、接着是实现了Ordered

2、其他实现了BeanDefinitionRegistryPostProcessor接口的调用

5.2.4、使用cjlib对beanFactory 做增强在判断是否是配置类时放入的full

```
invokeBeanFactoryPostProcessors(registryProcessors, beanFactory); //使用cjlib对beanFactory 做增强在判断是否是配置类时放入的full
invokeBeanFactoryPostProcessors(regularPostProcessors, beanFactory);
```

5.2.5、处理实现BeanFactoryPostProcessor接口的类

会从已经处理完的中筛选出还没有处理的接口

6、注册拦截Bean创建的Bean处理器，如果没有bean processors，此步骤什么也不做

> 注册所有的 BeanPostProcessor，将所有实现了 BeanPostProcessor 接口的类加载到 BeanFactory 中。
>
> BeanPostProcessor 接口是 Spring 初始化 bean 时对外暴露的扩展点，Spring IoC 容器允许 BeanPostProcessor 在容器初始化 bean 的前后，添加自己的逻辑处理。在 registerBeanPostProcessors 方法只是注册到 BeanFactory 中，具体调用是在 bean 初始化的时候。
>
> 具体的：在所有 bean 实例化时，执行初始化方法前会调用所有 BeanPostProcessor 的 postProcessBeforeInitialization 方法，在执行初始化方法后会调用所有 BeanPostProcessor 的 postProcessAfterInitialization 方法。

7、国际化处理 注册了一个bean(messageSource)

```
//Initialize message source for this context.在上下文初始化注册messageSource的bean，不同语言环境信息，国际化处理
initMessageSource();
```

8、在上下文初始化注册applicationEventMulticaster的bean，应用消息广播

给singletonObjects注册了一个applicationEventMulticaster对象

9、onRefresh()

然后创建并启动WebServer。SpringBoot内置的Tomcat或者UndertowWebServer就是在这里实例化的。

10、在所有bean中查找listener bean并注册到消息广播中，没有的话就什么也不做；

11、核心：初始化所有剩下的非延迟初始化的单例bean对象

（默认@Bean注解修饰的含有beanFactory）

11.1、ConversionService： 类型转换器 还有一个格式转换：PropertyEditorRegistrar

```
// Initialize conversion service for this context.
if (beanFactory.containsBean(CONVERSION_SERVICE_BEAN_NAME) &&
    beanFactory.isTypeMatch(CONVERSION_SERVICE_BEAN_NAME,
ConversionService.class)) {
    //设置conversionService的bean，与类型转换相关的bean
    beanFactory.setConversionService(
        beanFactory.getBean(CONVERSION_SERVICE_BEAN_NAME,
ConversionService.class));
}

//如果之前没有注册过任何 BeanFactoryPostProcessor（例如
PropertySourcesPlaceholderConfigurer bean），
// 则注册一个默认的嵌入值解析器：此时，主要用于解析注释属性值。
if (!beanFactory.hasEmbeddedValueResolver()) {  //给beanfactory添加一个值解析器
    beanFactory.addEmbeddedValueResolver(strVal ->
getEnvironment().resolvePlaceholders(strVal));
}

// 初始化运行时的代码织入，为AspectJ的支持（aop）
String[] weaverAwareNames =
beanFactory.getBeanNamesForType(LoadTimeWeaverAware.class, false, false);
for (String weaverAwareName : weaverAwareNames) {
    getBean(weaverAwareName);
}

// 停止使用临时的ClassLoader
beanFactory.setTempClassLoader(null);

//缓存所有的bean definition元信息，不希望未来发生变化
beanFactory.freezeConfiguration();

//TODO 实例化所有剩下的非延迟加载的单例bean Instantiate all remaining (non-lazy-init)
singletons.
beanFactory.preInstantiateSingletons();
```

11.2、创建bean并赋值

被@Bean修饰的类是一个工厂bean

```
//实例化所有剩下的非延迟加载的单例bean
    @Override
    public void preInstantiateSingletons() throws BeansException {
        if (logger.isTraceEnabled()) {
            logger.trace("Pre-instantiating singletons in " + this);
        }

        // Iterate over a copy to allow for init methods which in turn register
new bean definitions.
        // While this may not be part of the regular factory bootstrap, it does
otherwise work fine.
        List<String> beanNames = new ArrayList<>(this.beanDefinitionNames);

        // Trigger initialization of all non-lazy singleton beans... 循环迭代所有的
beanDefinition
        for (String beanName : beanNames) {
            RootBeanDefinition bd = getMergedLocalBeanDefinition(beanName);//根据
bean名字拿到BeanDefinition
            if (!bd.isAbstract() && bd.isSingleton() && !bd.isLazyInit()) {
                if (isFactoryBean(beanName)) {  //是否为工厂bean
                    Object bean = getBean(FACTORY_BEAN_PREFIX + beanName);
                    if (bean instanceof FactoryBean) {
                        FactoryBean<?> factory = (FactoryBean<?>) bean;
                        boolean isEagerInit;
                        if (System.getSecurityManager() != null && factory
instanceof SmartFactoryBean) {
                            isEagerInit = AccessController.doPrivileged(
                                    (PrivilegedAction<Boolean>)
((SmartFactoryBean<?>) factory)::isEagerInit,
                                    getAccessControlContext());
                        }
                        else {
                            isEagerInit = (factory instanceof SmartFactoryBean
&&
                                    ((SmartFactoryBean<?>)
factory).isEagerInit());
                        }
                        if (isEagerInit) {
                            getBean(beanName);
                        }
                    }
                }
                else { //TODO 不是工厂bean，用户配置的普通的bean将调这里，底层实现初始化
bean对象，并对bean对象赋值和依赖注入
                    getBean(beanName);
                }
            }
        }

        ///对bean初始化完成之后的回调
        for (String beanName : beanNames) {
            Object singletonInstance = getSingleton(beanName);
            if (singletonInstance instanceof SmartInitializingSingleton) {
```

```
                SmartInitializingSingleton smartSingleton =
(SmartInitializingSingleton) singletonInstance;
                if (System.getSecurityManager() != null) {
                    AccessController.doPrivileged((PrivilegedAction<Object>) ()
-> {
                        smartSingleton.afterSingletonsInstantiated();
                        return null;
                    }, getAccessControlContext());
                }
                else {
                    smartSingleton.afterSingletonsInstantiated();
                }
            }
        }
    }
```

1、普通bean创建

- ```
  public Object getBean(String name) throws BeansException {
      return doGetBean(name, null, null, false);
  }
  ```

- ```
  protected <T> T doGetBean(
      String name, @Nullable Class<T> requiredType, @Nullable Object[] args,
  boolean typeCheckOnly)
      throws BeansException {
      //对bean名字进行转换 (含有&符号的bean)
  (org.springframework.context.annotation.internalConfigurationAnnotationProce
  ssor)
      String beanName = transformedBeanName(name);
      Object bean;

      //TODO 获取单例bean对象 (isSingletonCurrentlyInCreatio判断是否是正在创建中)
      Object sharedInstance = getSingleton(beanName);
      if (sharedInstance != null && args == null) {
          if (logger.isTraceEnabled()) {
              if (isSingletonCurrentlyInCreation(beanName)) {
                  logger.trace("Returning eagerly cached instance of singleton
  bean '" + beanName +
                               "' that is not fully initialized yet - a
  consequence of a circular reference");
              }
              else {
                  logger.trace("Returning cached instance of singleton bean '"
  + beanName + "'");
              }
          }
          bean = getObjectForBeanInstance(sharedInstance, name, beanName,
  null);
      }

      else {
          // Fail if we're already creating this bean instance:
          // We're assumably within a circular reference.
          if (isPrototypeCurrentlyInCreation(beanName)) {
              throw new BeanCurrentlyInCreationException(beanName);
  ```

```
        }

        //检查父工厂 Check if bean definition exists in this factory.
        BeanFactory parentBeanFactory = getParentBeanFactory();
        if (parentBeanFactory != null && !containsBeanDefinition(beanName))
{
            // Not found -> check parent.
            String nameToLookup = originalBeanName(name);
            if (parentBeanFactory instanceof AbstractBeanFactory) {
                return ((AbstractBeanFactory) parentBeanFactory).doGetBean(
                    nameToLookup, requiredType, args, typeCheckOnly);
            }
            else if (args != null) {
                // Delegation to parent with explicit args.
                return (T) parentBeanFactory.getBean(nameToLookup, args);
            }
            else if (requiredType != null) {
                // No args -> delegate to standard getBean method.
                return parentBeanFactory.getBean(nameToLookup,
requiredType);
            }
            else {
                return (T) parentBeanFactory.getBean(nameToLookup);
            }
        }

        if (!typeCheckOnly) {
            markBeanAsCreated(beanName); // 标记该bean为已经创建状态，该状态改一
下，因为现在要开始创建了
        }

        try {

            RootBeanDefinition mbd = getMergedLocalBeanDefinition(beanName);
            checkMergedBeanDefinition(mbd, beanName, args); //检查是否为抽象
的，抽象的不能创建bean实例

            // Guarantee initialization of beans that the current bean
depends on.
            String[] dependsOn = mbd.getDependsOn();
            if (dependsOn != null) {
                for (String dep : dependsOn) {
                    if (isDependent(beanName, dep)) {
                        throw new
BeanCreationException(mbd.getResourceDescription(), beanName,
                                                              "Circular depends-on
relationship between '" + beanName + "' and '" + dep + "'");
                    }
                    registerDependentBean(dep, beanName);
                    try {
                        getBean(dep);
                    }
                    catch (NoSuchBeanDefinitionException ex) {
                        throw new
BeanCreationException(mbd.getResourceDescription(), beanName,
                                                              "'" + beanName + "'
depends on missing bean '" + dep + "'", ex);
                    }
```

```
                }
            }

            //  如果是单例的 Create bean instance.
            if (mbd.isSingleton()) { //获取实例化的 bean 对象
                sharedInstance = getSingleton(beanName, () -> {
                    try { //TODO 创建单例的bean实例
                        return createBean(beanName, mbd, args);
                    }
                    catch (BeansException ex) {
                        // Explicitly remove instance from singleton cache:
It might have been put there
                        // eagerly by the creation process, to allow for
circular reference resolution.
                        // Also remove any beans that received a temporary
reference to the bean.
                        destroySingleton(beanName);
                        throw ex;
                    }
                }); //TODO 检查bean实例，如果是bean返回本身，如果是工厂bean返回工厂
bean
                bean = getObjectForBeanInstance(sharedInstance, name,
beanName, mbd);
            }
            // 如果是多例的bean（每次新建）
            else if (mbd.isPrototype()) {
                // It's a prototype -> create a new instance.
                Object prototypeInstance = null;
                try {
                    beforePrototypeCreation(beanName);
                    prototypeInstance = createBean(beanName, mbd, args);
                }
                finally {
                    afterPrototypeCreation(beanName);
                }
                bean = getObjectForBeanInstance(prototypeInstance, name,
beanName, mbd);
            }

            else {
                String scopeName = mbd.getScope();
                if (!StringUtils.hasLength(scopeName)) {
                    throw new IllegalStateException("No scope name defined
for bean '" + beanName + "'");
                }
                Scope scope = this.scopes.get(scopeName);
                if (scope == null) {
                    throw new IllegalStateException("No Scope registered for
scope name '" + scopeName + "'");
                }
                try {
                    Object scopedInstance = scope.get(beanName, () -> {
                        beforePrototypeCreation(beanName);
                        try {
                            return createBean(beanName, mbd, args);
                        }
                        finally {
                            afterPrototypeCreation(beanName);
```

```
                        }
                    });
                    bean = getObjectForBeanInstance(scopedInstance, name,
beanName, mbd);
                }
                catch (IllegalStateException ex) {
                    throw new BeanCreationException(beanName,
                                                    "Scope '" + scopeName +
"' is not active for the current thread; consider " +
                                                    "defining a scoped proxy
for this bean if you intend to refer to it from a singleton",
                                                    ex);
                }
            }
        }
        catch (BeansException ex) {
            cleanupAfterBeanCreationFailure(beanName);
            throw ex;
        }
    }
```

1）判断是否正在创建中（解决循环依赖）

singletonObject：一级缓存，存放的是创建成功切赋值后的bean。递归调用，当前方法为

earlySingletonObjects： 二级缓存，在创建成功bean对象后放入

singletonFactories：三级缓存，创建单例BEAN的工厂

如果允许提前暴露bean，将初始化的bean放入三级缓存singletonFactories，bean在赋值时会若有注入，会递归调用程序

先从一级缓存singletonObjects中去获取。（如果获取到就直接return）
如果获取不到或者对象正在创建中（isSingletonCurrentlyInCreation()），那就再从二级缓存earlySingletonObjects中获取。（如果获取到就直接return）
如果还是获取不到，且允许singletonFactories（allowEarlyReference=true）通过getObject()获取。就从三级缓存singletonFactory.getObject()获取。（如果获取到了就从singletonFactories中移除，并且放进earlySingletonObjects。其实也就是从三级缓存移动（是剪切、不是复制哦~）到了二级缓存）此处的移动保证了，之后在init时候仍然是同一个对象

```
@Nullable
protected Object getSingleton(String beanName, boolean allowEarlyReference) {
    //从singletonObjects这个Map中获取bean对象，如果存在，则不需要创建 Quick check for
existing instance without full singleton lock
    Object singletonObject = this.singletonObjects.get(beanName);
    if (singletonObject == null && isSingletonCurrentlyInCreation(beanName)) {
   // （循环依赖）如果缓存中不存在目标对象，则判断当前对象是否已经处于创建过程中，在前面的第一次
尝试获取该对象、// 的实例之后，就会将该对象标记为正在创建中，因而此处尝试获取该对象的时候，if判
断就会为true
        singletonObject = this.earlySingletonObjects.get(beanName); //早期单例对象
        if (singletonObject == null && allowEarlyReference) {
            synchronized (this.singletonObjects) {
                // Consistent creation of early reference within full singleton
lock
                singletonObject = this.singletonObjects.get(beanName);
                if (singletonObject == null) {
                    singletonObject = this.earlySingletonObjects.get(beanName);
                    if (singletonObject == null) {
```

```
                        ObjectFactory<?> singletonFactory =
this.singletonFactories.get(beanName);
                        if (singletonFactory != null) {
                            singletonObject = singletonFactory.getObject();
                            this.earlySingletonObjects.put(beanName,
singletonObject);
                            this.singletonFactories.remove(beanName);
                        }
                    }
                }
            }
        }
    }
    return singletonObject;
}

//判断是否是在创建中isSingletonCurrentlyInCreation(beanName)在上面代码中标记
public boolean isSingletonCurrentlyInCreation(String beanName) {
    return this.singletonsCurrentlyInCreation.contains(beanName);
}
```

2）应用BeanPostProcessors处理器以及单例bean创建

```
InstantiationAwareBeanPostProcessor.class
```

```
public Object getSingleton(String beanName, ObjectFactory<?> singletonFactory) {
        Assert.notNull(beanName, "Bean name must not be null");
        synchronized (this.singletonObjects) {
            Object singletonObject = this.singletonObjects.get(beanName);
            if (singletonObject == null) {
                if (this.singletonsCurrentlyInDestruction) {
                    throw new BeanCreationNotAllowedException(beanName,
                            "Singleton bean creation not allowed while
singletons of this factory are in destruction " +
                            "(Do not request a bean from a BeanFactory in a
destroy method implementation!)");
                }
                if (logger.isDebugEnabled()) {
                    logger.debug("Creating shared instance of singleton bean '"
+ beanName + "'");
                }//创建之前检查是否创建过   2、
this.singletonsCurrentlyInCreation.add(beanName)  给目前正在创建的singletons Beand对
象放入
                beforeSingletonCreation(beanName);
                boolean newSingleton = false;
                boolean recordSuppressedExceptions = (this.suppressedExceptions
== null);
                if (recordSuppressedExceptions) {
                    this.suppressedExceptions = new LinkedHashSet<>();
                }
                try {
                    //TODO 得到单例的bean实例
                    singletonObject = singletonFactory.getObject();
                    newSingleton = true;
                }
                catch (IllegalStateException ex) {
```

```
                    // Has the singleton object implicitly appeared in the
meantime ->
                    // if yes, proceed with it since the exception indicates
that state.
                    singletonObject = this.singletonObjects.get(beanName);
                    if (singletonObject == null) {
                        throw ex;
                    }
                }
                catch (BeanCreationException ex) {
                    if (recordSuppressedExceptions) {
                        for (Exception suppressedException :
this.suppressedExceptions) {
                            ex.addRelatedCause(suppressedException);
                        }
                    }
                    throw ex;
                }
                finally {
                    if (recordSuppressedExceptions) {
                        this.suppressedExceptions = null;
                    }
                    afterSingletonCreation(beanName);
                }
                if (newSingleton) { //TODO 如果是一个新的bean对象，把bean放入Map中 (此
map就是spring ioc容器)
                    addSingleton(beanName, singletonObject);
                }
            }//返回单例对象
            return singletonObject;
        }
    }
```

- 得到单例的bean实例：singletonObject = singletonFactory.getObject();

  beanName：springConfig

  mbd：bean定义

  args：null

```
try { //TODO 创建单例的bean实例
    return createBean(beanName, mbd, args);
}
catch (BeansException ex) {
    // Explicitly remove instance from singleton cache: It might have been put
there
    // eagerly by the creation process, to allow for circular reference
resolution.
    // Also remove any beans that received a temporary reference to the bean.
    destroySingleton(beanName);
    throw ex;
}
}); //TODO 检查bean实例，如果是bean返回本身，如果是工厂bean返回工厂bean
bean = getObjectForBeanInstance(sharedInstance, name, beanName, mbd);
}
```

- ```
  //createBean:
  ```
  ```

```
//mbdToUse:bean定义

try {
    /*如果Bean配置了初始化前和初始化后的处理器，则试图返回一个需要创建Bean的代理对象*/
    //TODO 第一次调用bean的后置处理器 主要判断bean需要被代理  bean一般都为空 ：
InstantiationAwareBeanPostProcessor
    Object bean = resolveBeforeInstantiation(beanName, mbdToUse);
    if (bean != null) {
        return bean;
    }
}
try {
    //TODO 创建bean
    Object beanInstance = doCreateBean(beanName, mbdToUse, args);
    if (logger.isTraceEnabled()) {
        logger.trace("Finished creating instance of bean '" + beanName +
"'");
    }
    return beanInstance;
}

Object bean = instanceWrapper.getWrappedInstance();
Class<?> beanType = instanceWrapper.getWrappedClass();
if (beanType != NullBean.class) {
    mbd.resolvedTargetType = beanType;
}
// 应用BeanPostProcessors处理器 允许post-processors修改bean definition
synchronized (mbd.postProcessingLock) {
    if (!mbd.postProcessed) {
        try {
            //应用Bean定义后处理器  MergedBeanDefinitionPostProcessor
            applyMergedBeanDefinitionPostProcessors(mbd, beanType,
beanName);
        }
        catch (Throwable ex) {
            throw new BeanCreationException(mbd.getResourceDescription(),
beanName,
                                            "Post-processing of merged bean
definition failed", ex);
        }
        mbd.postProcessed = true;
    }
}
// 判断Spring是否配置了支持提前暴露目标bean，也就是是否支持提前暴露半成品的bean
boolean earlySingletonExposure = (mbd.isSingleton() &&
this.allowCircularReferences &&
                                  isSingletonCurrentlyInCreation(beanName));
if (earlySingletonExposure) {
    if (logger.isTraceEnabled()) {
        logger.trace("Eagerly caching bean '" + beanName +
                     "' to allow for resolving potential circular
references");
    } // 如果支持提前暴露目标bean，将当前生成的半成品的bean放到singletonFactories(三
级缓存)中
    addSingletonFactory(beanName, () -> getEarlyBeanReference(beanName, mbd,
bean));
}
```

```
// Initialize the bean instance.
Object exposedObject = bean;
try {
    //TODO 填充bean的属性值，给bean赋值和注入依赖 如果当前bean依赖了其他的bean，则会递归的调用beanFactory.getBean()方法尝试获取目标bean
    populateBean(beanName, mbd, instanceWrapper);
    exposedObject = initializeBean(beanName, exposedObject, mbd); //TODO 对原始bean对象进行增强，产生代理对象
}

if (earlySingletonExposure) {
    Object earlySingletonReference = getSingleton(beanName, false);
    if (earlySingletonReference != null) {
        if (exposedObject == bean) {
            exposedObject = earlySingletonReference;
        }
        else if (!this.allowRawInjectionDespiteWrapping &&
hasDependentBean(beanName)) {
            String[] dependentBeans = getDependentBeans(beanName);
            Set<String> actualDependentBeans = new LinkedHashSet<>
(dependentBeans.length);
            for (String dependentBean : dependentBeans) {
                if
(!removeSingletonIfCreatedForTypeCheckOnly(dependentBean)) {
                    actualDependentBeans.add(dependentBean);
                }
            }


// Register bean as disposable.
try {
    registerDisposableBeanIfNecessary(beanName, bean, mbd);
}
catch (BeanDefinitionValidationException ex) {
    throw new BeanCreationException(
        mbd.getResourceDescription(), beanName, "Invalid destruction
signature", ex);
}

return exposedObject;
}
```

- ```
  //doCreateBean:
  BeanWrapper instanceWrapper = null;
  if (mbd.isSingleton()) {
      instanceWrapper = this.factoryBeanInstanceCache.remove(beanName);
  }
  if (instanceWrapper == null) {
      //创建bean实例
      instanceWrapper = createBeanInstance(beanName, mbd, args);
  }

  Object bean = instanceWrapper.getWrappedInstance();
  Class<?> beanType = instanceWrapper.getWrappedClass();
  if (beanType != NullBean.class) {
      mbd.resolvedTargetType = beanType;
  }
  ```
  ```

```
// 应用BeanPostProcessors处理器 允许post-processors修改bean definition
synchronized (mbd.postProcessingLock) {
    if (!mbd.postProcessed) {
        try {
            //应用Bean定义后处理器
            applyMergedBeanDefinitionPostProcessors(mbd, beanType,
beanName);
        }
        catch (Throwable ex) {
            throw new BeanCreationException(mbd.getResourceDescription(),
beanName,
                                            "Post-processing of merged bean
definition failed", ex);
        }
        mbd.postProcessed = true;
    }
}
// 判断Spring是否配置了支持提前暴露目标bean，也就是是否支持提前暴露半成品的bean
boolean earlySingletonExposure = (mbd.isSingleton() &&
this.allowCircularReferences &&
                                  isSingletonCurrentlyInCreation(beanName));
if (earlySingletonExposure) {
    // 如果支持提前暴露目标bean，将当前生成的半成品的bean放到singletonFactories(三级
缓存)中
    addSingletonFactory(beanName, () -> getEarlyBeanReference(beanName, mbd,
bean));
}

// Initialize the bean instance.
Object exposedObject = bean;
try { //TODO 填充bean的属性值，给bean赋值和注入依赖 如果当前bean依赖了其他的bean，则会
递归的调用beanFactory.getBean()方法尝试获取目标bean
    populateBean(beanName, mbd, instanceWrapper);
    exposedObject = initializeBean(beanName, exposedObject, mbd); //TODO 对原
始bean对象进行增强，产生代理对象
}
```

- ```
  //createBeanInstance:
  protected BeanWrapper createBeanInstance(String beanName, RootBeanDefinition
  mbd, @Nullable Object[] args) {
      // Make sure bean class is actually resolved at this point.
      Class<?> beanClass = resolveBeanClass(mbd, beanName);

      if (beanClass != null && !Modifier.isPublic(beanClass.getModifiers()) &&
  !mbd.isNonPublicAccessAllowed()) {
          throw new BeanCreationException(mbd.getResourceDescription(),
  beanName,
                                          "Bean class isn't public, and non-
  public access not allowed: " +            beanClass.getName());
      }
      //如果存在 Supplier 回调，则调用 obtainFromSupplier() 进行初始化
      Supplier<?> instanceSupplier = mbd.getInstanceSupplier();
      if (instanceSupplier != null) {
          return obtainFromSupplier(instanceSupplier, beanName);
      }
      //如果工厂方法不为空，则使用工厂方法初始化策略(@Bean默认创建方式为beanFactory)
      if (mbd.getFactoryMethodName() != null) {
  ```
  ```

```
            return instantiateUsingFactoryMethod(beanName, mbd, args);
        }

        // Shortcut when re-creating the same bean...
        boolean resolved = false;
        boolean autowireNecessary = false;
        if (args == null) {
            synchronized (mbd.constructorArgumentLock) {
                if (mbd.resolvedConstructorOrFactoryMethod != null) {
                    resolved = true;
                    autowireNecessary = mbd.constructorArgumentsResolved;
                }
            }
        } // 已经解析好了，直接注入即可
        if (resolved) {
            if (autowireNecessary) { // 自动注入，调用构造函数自动注入
                return autowireConstructor(beanName, mbd, null, null);
            }
            else { // 使用默认构造函数构造
                return instantiateBean(beanName, mbd);
            }
        }
//      TODO 第二次调用后置处理器推断构造方法 下面是单例对象的  使用Bean的构造方法进行实例化    自动注入 --通过构造方法自动注入
//      2.1、如果有多个构造方法  找出最优的构造器 参数最多的 为最优的
//      TODO spring 通过构造方法实例化 bean的原理
//      实例化这个对象---首先要推断构造方法
//      这个分两种类型
//      1、手动注入
//      会在后置处理器中 找到实现 SmartInstantiationAwareBeanPostProcessor接口的类型
//      AutowiredAnnotationBeanPostProcessor类中的 determineCandidateConstructors 方法来推断出
//      合适的构造方法创建对象
//      1.1、只有一个无参构造方法 ctors为 null 使用默认无参构造方法
//      1.2 如果有多个构造方法 ctors为 null 使用默认无参构造方法
//      1.3  如果只有一个有参构造方法 ctors不为null 因为只有一个有参数的 只能用这个了
//      1.4、多个构造方法 且只有一个构造方法加了@Autowired(required = true) 用这个构造方法来创建对象
//      1.5、多个构造方法 且多个构造方法加了@Autowired(required = true)  spring ioc容器报错
//      1.6、多个构造方法 且多个构造方法加了@Autowired(required = false)  就把构造方法都加到集合中 第二次推断
//      2、自动注入 --通过构造方法自动注入
//      2.1、如果有多个构造方法  找出最优的构造器 参数最多的 为最优的
        // Candidate constructors for autowiring?
        Constructor<?>[] ctors = determineConstructorsFromBeanPostProcessors(beanClass, beanName);
        if (ctors != null || mbd.getResolvedAutowireMode() == AUTOWIRE_CONSTRUCTOR ||
            mbd.hasConstructorArgumentValues() || !ObjectUtils.isEmpty(args)) {
            return autowireConstructor(beanName, mbd, ctors, args);
        }

        // Preferred constructors for default construction?
        ctors = mbd.getPreferredConstructors();
        if (ctors != null) {
            return autowireConstructor(beanName, mbd, ctors, null);
```

```
        }

        // 使用默认构造函数构造 No special handling: simply use no-arg constructor.
        return instantiateBean(beanName, mbd);
        }
```

2.1使用默认构造函数构造

```
//instantiateBean:
try {
    Object beanInstance;
    if (System.getSecurityManager() != null) {
        beanInstance = AccessController.doPrivileged(
            (PrivilegedAction<Object>) () ->
getInstantiationStrategy().instantiate(mbd, beanName, this),
            getAccessControlContext());
    }
    else {
        //TODO 此处真正地创建了 bean 的实例对象，底层依然是反射
getInstantiationStrategy：实例化策略
        beanInstance = getInstantiationStrategy().instantiate(mbd, beanName,
this);
    }
    BeanWrapper bw = new BeanWrapperImpl(beanInstance);
    initBeanWrapper(bw); //类型转化器 对不同Class类型进行相应的转换。比如String转成
Boolean. Boolean转成string类.以下是个简单的例子
    return bw;
}
```

```
public Object instantiate(RootBeanDefinition bd, @Nullable String beanName,
BeanFactory owner) {
    // Don't override the class with CGLIB if no overrides.
    if (!bd.hasMethodOverrides()) {
        Constructor<?> constructorToUse;
        synchronized (bd.constructorArgumentLock) {
            constructorToUse = (Constructor<?>)
bd.resolvedConstructorOrFactoryMethod;
            if (constructorToUse == null) { //得到bean的class类
                final Class<?> clazz = bd.getBeanClass();
                if (clazz.isInterface()) {
                    throw new BeanInstantiationException(clazz, "Specified class
is an interface");
                }
                try {
                    if (System.getSecurityManager() != null) {
                        constructorToUse = AccessController.doPrivileged(
                            (PrivilegedExceptionAction<Constructor<?>>)
clazz::getDeclaredConstructor);
                    }
                    else { //获取声明的构造函数
                        constructorToUse = clazz.getDeclaredConstructor();
                    }
                    bd.resolvedConstructorOrFactoryMethod = constructorToUse;
                }
                catch (Throwable ex) {
```

```
                    throw new BeanInstantiationException(clazz, "No default
constructor found", ex);
                }
            }
        } //TODO 得到类的构造器 (构造方法)
        return BeanUtils.instantiateClass(constructorToUse);
    }
```

```
public static <T> T instantiateClass(Constructor<T> ctor, Object... args) throws
BeanInstantiationException {
    Assert.notNull(ctor, "Constructor must not be null");
    try {
        ReflectionUtils.makeAccessible(ctor); //解除私有限定
        if (KotlinDetector.isKotlinReflectPresent() &&
KotlinDetector.isKotlinType(ctor.getDeclaringClass())) {
            return KotlinDelegate.instantiateClass(ctor, args);
        }
        else {
            //获取参数类型
            Class<?>[] parameterTypes = ctor.getParameterTypes();
            Assert.isTrue(args.length <= parameterTypes.length, "Can't specify
more arguments than constructor parameters");
            Object[] argsWithDefaultValues = new Object[args.length];
            for (int i = 0 ; i < args.length; i++) {
                if (args[i] == null) {
                    Class<?> parameterType = parameterTypes[i];
                    argsWithDefaultValues[i] = (parameterType.isPrimitive() ?
DEFAULT_TYPE_VALUES.get(parameterType) : null);
                }
                else {
                    argsWithDefaultValues[i] = args[i];
                }
            }
            return ctor.newInstance(argsWithDefaultValues);
        }
    }
```

2.2类型转换器：PropertyEditorRegistrar

在实例化完成使用，转换格式：

```
public class CustomDateEditorRegistrar implements PropertyEditorRegistrar {

    @Override
    public void registerCustomEditors(PropertyEditorRegistry registry) {
        registry.registerCustomEditor(Date.class, new CustomDateEditor(new
SimpleDateFormat("yyyy/MM/dd"), true));
    }
}
```

3）允许后处理程序修改合并的bean定义。

```
// 应用BeanPostProcessors处理器 允许post-processors修改bean definition
MergedBeanDefinitionPostProcessor
// Allow post-processors to modify the merged bean definition.
synchronized (mbd.postProcessingLock) {
```

```
    if (!mbd.postProcessed) {
        try { //应用Bean定义后处理器
            applyMergedBeanDefinitionPostProcessors(mbd, beanType, beanName);
        }
        catch (Throwable ex) {
            throw new BeanCreationException(mbd.getResourceDescription(),
beanName,
                                            "Post-processing of merged bean
definition failed", ex);
        }
        mbd.postProcessed = true;
    }
}
```

4) 判断Spring是否配置了支持提前暴露目标bean，也就是是否支持提前暴露半成品的bean

```
boolean earlySingletonExposure = (mbd.isSingleton() &&
this.allowCircularReferences &&
                                  isSingletonCurrentlyInCreation(beanName));
if (earlySingletonExposure) {
    if (logger.isTraceEnabled()) {
        logger.trace("Eagerly caching bean '" + beanName +
                     "' to allow for resolving potential circular references");
    } // 如果支持提前暴露目标bean，将当前生成的半成品的bean放到singletonFactories(三级缓
存)中
    addSingletonFactory(beanName, () -> getEarlyBeanReference(beanName, mbd,
bean));
}

protected void addSingletonFactory(String beanName, ObjectFactory<?>
singletonFactory) {
    Assert.notNull(singletonFactory, "Singleton factory must not be null");
    synchronized (this.singletonObjects) {
        if (!this.singletonObjects.containsKey(beanName)) {
            this.singletonFactories.put(beanName, singletonFactory); //存放到
            this.earlySingletonObjects.remove(beanName);
            this.registeredSingletons.add(beanName);
        }
    }
}

//会存放到三级缓存中singletonFactories
```

5）填充bean的属性值，给bean赋值和注入依赖 如果当前bean依赖了其他的bean，则会递归的调用beanFactory.getBean()方法尝试获取目标bean

```
populateBean(beanName, mbd, instanceWrapper);//给bean赋值和注入依赖 如果当前bean依赖了
其他的bean，则会递归的调用beanFactory.getBean()方法尝试获取目标bean
exposedObject = initializeBean(beanName, exposedObject, mbd); //TODO 对原始bean对
象进行增强，产生代理对象(AOP会将对象转为代理类)
```

5.1、填充bean的属性值

```
protected void populateBean(String beanName, RootBeanDefinition mbd, @Nullable
BeanWrapper bw) {

    // 实现InstantiationAwareBeanPostProcessors 在设置属性之前修改bean状态的机会。例
如，这可以用于支持字段注入的样式。
    if (!mbd.isSynthetic() && hasInstantiationAwareBeanPostProcessors()) {
        for (BeanPostProcessor bp : getBeanPostProcessors()) {
            if (bp instanceof InstantiationAwareBeanPostProcessor) {
                InstantiationAwareBeanPostProcessor ibp =
(InstantiationAwareBeanPostProcessor) bp;
                if (!ibp.postProcessAfterInstantiation(bw.getWrappedInstance(),
beanName)) {
                    return;
                }
            }
        }
    }

    PropertyValues pvs = (mbd.hasPropertyValues() ? mbd.getPropertyValues() :
null);

    int resolvedAutowireMode = mbd.getResolvedAutowireMode();
    if (resolvedAutowireMode == AUTOWIRE_BY_NAME || resolvedAutowireMode ==
AUTOWIRE_BY_TYPE) {
        MutablePropertyValues newPvs = new MutablePropertyValues(pvs);
        // Add property values based on autowire by name if applicable.
        if (resolvedAutowireMode == AUTOWIRE_BY_NAME) {
            autowireByName(beanName, mbd, bw, newPvs);
        }
        // Add property values based on autowire by type if applicable.
        if (resolvedAutowireMode == AUTOWIRE_BY_TYPE) {
            autowireByType(beanName, mbd, bw, newPvs);
        }
        pvs = newPvs;
    }

    boolean hasInstAwareBpps = hasInstantiationAwareBeanPostProcessors();
    boolean needsDepCheck = (mbd.getDependencyCheck() !=
AbstractBeanDefinition.DEPENDENCY_CHECK_NONE);

    PropertyDescriptor[] filteredPds = null;
    if (hasInstAwareBpps) {
        if (pvs == null) {
            pvs = mbd.getPropertyValues();
        }
        //TODO BeanPostProcessor的处理（@Autowired注解的postprocessor）
        for (BeanPostProcessor bp : getBeanPostProcessors()) {
            if (bp instanceof InstantiationAwareBeanPostProcessor) {
                InstantiationAwareBeanPostProcessor ibp =
(InstantiationAwareBeanPostProcessor) bp;
                PropertyValues pvsToUse = ibp.postProcessProperties(pvs,
bw.getWrappedInstance(), beanName);
                if (pvsToUse == null) {
                    if (filteredPds == null) {
```

```
                        filteredPds =
filterPropertyDescriptorsForDependencyCheck(bw, mbd.allowCaching);
                    }
                    pvsToUse = ibp.postProcessPropertyValues(pvs, filteredPds,
bw.getWrappedInstance(), beanName);
                    if (pvsToUse == null) {
                        return;
                    }
                }
                pvs = pvsToUse;
            }
        }
    }
    if (needsDepCheck) {
        if (filteredPds == null) {
            filteredPds = filterPropertyDescriptorsForDependencyCheck(bw,
mbd.allowCaching);
        }
        checkDependencies(beanName, mbd, filteredPds, pvs);
    }
    //TODO 填充值
    if (pvs != null) {
        applyPropertyValues(beanName, mbd, bw, pvs);
    }
}
```

5.1.1、@Autowried依赖注入(循环依赖)

```
 //TODO BeanPostProcessor的处理（@Autowired注解的postprocessor）
ibp.postProcessProperties
public PropertyValues postProcessProperties(PropertyValues pvs, Object bean,
String beanName) {
    //根据我们的myBean寻找到需要注入的HeBean
    InjectionMetadata metadata = findAutowiringMetadata(beanName,
bean.getClass(), pvs);
    try {
        metadata.inject(bean, beanName, pvs);
    }
    catch (BeanCreationException ex) {
        throw ex;
    }
    catch (Throwable ex) {
        throw new BeanCreationException(beanName, "Injection of autowired
dependencies failed", ex);
    }
    return pvs;
}

//inject:
//target：myBean、beanName：myBean、 pvs：参数
public void inject(Object target, @Nullable String beanName, @Nullable
PropertyValues pvs) throws Throwable {
    Collection<InjectedElement> checkedElements = this.checkedElements;
    Collection<InjectedElement> elementsToIterate =
        (checkedElements != null ? checkedElements : this.injectedElements);
    if (!elementsToIterate.isEmpty()) {
        for (InjectedElement element : elementsToIterate) {
```

```
            //@Autowried依赖注入
            element.inject(target, beanName, pvs);
        }
    }
}
//
protected void inject(Object bean, @Nullable String beanName, @Nullable
PropertyValues pvs) throws Throwable {
   //heBean 成员变量的信息 private com.cs.bean.HeBean com.cs.bean.MyBean.heBean
    Field field = (Field) this.member;
    Object value;
    if (this.cached) {
        try {
            value = resolvedCachedArgument(beanName, this.cachedFieldValue);
        }
        catch (NoSuchBeanDefinitionException ex) {
            // Unexpected removal of target bean for cached argument -> re-
resolve
            value = resolveFieldValue(field, bean, beanName);
        }
    }
    else {
        //处理要依赖的对象
        value = resolveFieldValue(field, bean, beanName);
    }
    if (value != null) {
        ReflectionUtils.makeAccessible(field);
        field.set(bean, value);
    }
}

private Object resolveFieldValue(Field field, Object bean, @Nullable String
beanName) {
    //field的封装
    DependencyDescriptor desc = new DependencyDescriptor(field, this.required);
    desc.setContainingClass(bean.getClass());
    //注入的对象的名字
    Set<String> autowiredBeanNames = new LinkedHashSet<>(1);
    Assert.state(beanFactory != null, "No BeanFactory available");
    //类型转化
    TypeConverter typeConverter = beanFactory.getTypeConverter();
    Object value;
    try {
        //去处理要依赖的对象
        value = beanFactory.resolveDependency(desc, beanName,
autowiredBeanNames, typeConverter);
    }
    catch (BeansException ex) {
        throw new UnsatisfiedDependencyException(null, beanName, new
InjectionPoint(field), ex);
    }
    synchronized (this) {
        if (!this.cached) {
            Object cachedFieldValue = null;
            if (value != null || this.required) {
                cachedFieldValue = desc;
                registerDependentBeans(beanName, autowiredBeanNames);
                if (autowiredBeanNames.size() == 1) {
```

```
                    String autowiredBeanName =
autowiredBeanNames.iterator().next();
                    if (beanFactory.containsBean(autowiredBeanName) &&
                        beanFactory.isTypeMatch(autowiredBeanName,
field.getType())) {
                        cachedFieldValue = new ShortcutDependencyDescriptor(
                            desc, autowiredBeanName, field.getType());
                    }
                }
            }
            this.cachedFieldValue = cachedFieldValue;
            this.cached = true;
        }
    }
    return value;
}

public Object resolveDependency(DependencyDescriptor descriptor, @Nullable
String requestingBeanName,
            @Nullable Set<String> autowiredBeanNames, @Nullable TypeConverter
typeConverter) throws BeansException {

    descriptor.initParameterNameDiscovery(getParameterNameDiscoverer());
    if (Optional.class == descriptor.getDependencyType()) {
        return createOptionalDependency(descriptor, requestingBeanName);
    }
    else if (ObjectFactory.class == descriptor.getDependencyType() ||
             ObjectProvider.class == descriptor.getDependencyType()) {
        return new DependencyObjectProvider(descriptor, requestingBeanName);
    }
    else if (javaxInjectProviderClass == descriptor.getDependencyType()) {
        return new Jsr330Factory().createDependencyProvider(descriptor,
requestingBeanName);
    }
    else {
        Object result =
getAutowireCandidateResolver().getLazyResolutionProxyIfNecessary(
            descriptor, requestingBeanName);
        if (result == null) {
            //解析需要依赖注入的对象
            result = doResolveDependency(descriptor, requestingBeanName,
autowiredBeanNames, typeConverter);
        }
        return result;
    }
}

public Object doResolveDependency {
    //解析候选者bean，会调用beanFactory.getBean()方法获取bean，该方法内部会进行初始化
    instanceCandidate = descriptor.resolveCandidate(autowiredBeanName, type,
this);
}
public Object resolveCandidate(String beanName, Class<?> requiredType,
BeanFactory beanFactory)
    throws BeansException {

    return beanFactory.getBean(beanName);
}
```

```
//递归回去创建bean
@Override
public Object getBean(String name) throws BeansException {
    return doGetBean(name, null, null, false);
}
```

假设容器首先创建HeBean：

1、创建HeBean对象：反射 （此时MyBean还没有创建）

2、把“heBean”放入 singletonFactories的Map中：
```
this.singletonFactories.put(beanName, singletonFactory);
this.earlySingletonObjects.remove(beanName);
```

3、给heBean设置属性值（也就是给heBean的成员变量赋值）

4、当HeBean依赖了MyBean，而MyBean还没有创建，此时HeBean无法完成属性赋值，HeBean还是一个半成品，然后就跳到了：beanFactory.getBean(“myBean”)；（递归到了获取bean的入口处）

5、开始创建MyBean对象

1、创建MyBean对象：反射 （此时HeBean是个半成品）

2、把“myBean”放入 ingletonFactories的Map
```
this.singletonFactories.put(beanName, singletonFactory);
this.earlySingletonObjects.remove(beanName);
```

3、给myBean设置属性值（也就是给MyBean的成员变量赋值）

4、MyBean此时是一个半成品，此时代码：

```
//解析候选者bean，会调beanFactory.getBean()方法获取bean，该方法内部会进行初始化
instanceCandidate = descriptor.resolveCandidate(autowiredBeanName, type,
this);
```

此时并没有完成heBean属性设置然后就跳到了：beanFactory.getBean(“heBean”);（递归到了获取bean的入口处）

去入口处：
```
public Object resolveCandidate(String beanName, Class<?> requiredType,
BeanFactory beanFactory) throws BeansException {
    //根据bean名称获取bean对象
    return beanFactory.getBean(beanName);
}
```

5、从这里获取heBean：

5.1.2、填充值

```
protected void applyPropertyValues(String beanName, BeanDefinition mbd,
BeanWrapper bw, PropertyValues pvs) {
    if (pvs.isEmpty()) {
        return;
    }
```

```
    if (System.getSecurityManager() != null && bw instanceof BeanWrapperImpl) {
        ((BeanWrapperImpl) bw).setSecurityContext(getAccessControlContext());
    }

    MutablePropertyValues mpvs = null;
    List<PropertyValue> original;

    if (pvs instanceof MutablePropertyValues) {
        mpvs = (MutablePropertyValues) pvs;
        if (mpvs.isConverted()) {
            // Shortcut: use the pre-converted values as-is.
            try {
                bw.setPropertyValues(mpvs);
                return;
            }
            catch (BeansException ex) {
                throw new BeanCreationException(
                    mbd.getResourceDescription(), beanName, "Error setting
property values", ex);
            }
        }
        //得到属性值
        original = mpvs.getPropertyValueList();
    }
    else {
        original = Arrays.asList(pvs.getPropertyValues());
    }

    TypeConverter converter = getCustomTypeConverter();
    if (converter == null) {
        converter = bw;
    }
    //BeanDefinition的值解析对象
    BeanDefinitionValueResolver valueResolver = new
BeanDefinitionValueResolver(this, beanName, mbd, converter);

    // Create a deep copy, resolving any references for values.
    List<PropertyValue> deepCopy = new ArrayList<>(original.size());
    boolean resolveNecessary = false;
    for (PropertyValue pv : original) {
        if (pv.isConverted()) {
            deepCopy.add(pv);
        }
        else {
            String propertyName = pv.getName();
            Object originalValue = pv.getValue();
            if (originalValue == AutowiredPropertyMarker.INSTANCE) {
                Method writeMethod =
bw.getPropertyDescriptor(propertyName).getWriteMethod();
                if (writeMethod == null) {
                    throw new IllegalArgumentException("Autowire marker for
property without write method: " + pv);
                }
                originalValue = new DependencyDescriptor(new
MethodParameter(writeMethod, 0), true);
            }
            Object resolvedValue = valueResolver.resolveValueIfNecessary(pv,
originalValue);
```

```
            Object convertedValue = resolvedValue;
            boolean convertible = bw.isWritableProperty(propertyName) &&
                !PropertyAccessorUtils.isNestedOrIndexedProperty(propertyName);
            if (convertible) {
                convertedValue = convertForProperty(resolvedValue, propertyName,
bw, converter);
            }
            // Possibly store converted value in merged bean definition,
            // in order to avoid re-conversion for every created bean instance.
            if (resolvedValue == originalValue) {
                if (convertible) {
                    pv.setConvertedValue(convertedValue);
                }
                deepCopy.add(pv);
            }
            else if (convertible && originalValue instanceof TypedStringValue &&
                    !((TypedStringValue) originalValue).isDynamic() &&
                    !(convertedValue instanceof Collection ||
ObjectUtils.isArray(convertedValue))) {
                pv.setConvertedValue(convertedValue);
                deepCopy.add(pv);
            }
            else {
                resolveNecessary = true;
                deepCopy.add(new PropertyValue(pv, convertedValue));
            }
        }
    }
    if (mpvs != null && !resolveNecessary) {
        mpvs.setConverted();
    }

    // Set our (possibly massaged) deep copy.
    try {
        bw.setPropertyValues(new MutablePropertyValues(deepCopy));
    }
    catch (BeansException ex) {
        throw new BeanCreationException(
            mbd.getResourceDescription(), beanName, "Error setting property
values", ex);
    }
}
```

6）初始化（aop在此步骤将bean变为代理对象）

各种Aware调用

> ```
> BeanPostProcessor.postProcessBeforeInitialization
> 初始化
> BeanPostProcessor.postProcessAfterInitialization
> ```

```
exposedObject = initializeBean(beanName, exposedObject, mbd); //TODO 对原始bean对象进行增强，产生代理对象(AOP会将对象转为代理类)
```

```
protected Object initializeBean(String beanName, Object bean, @Nullable
RootBeanDefinition mbd) {
```

```
    if (System.getSecurityManager() != null) {
        AccessController.doPrivileged((PrivilegedAction<Object>) () -> {
            invokeAwareMethods(beanName, bean);
            return null;
        }, getAccessControlContext());
    }
    else {
        invokeAwareMethods(beanName, bean);
    }

    Object wrappedBean = bean;
    if (mbd == null || !mbd.isSynthetic()) {
        //在初始化前应用Bean后处理器
        wrappedBean = applyBeanPostProcessorsBeforeInitialization(wrappedBean,
beanName);
    }

    try {
        //初始化init
        invokeInitMethods(beanName, wrappedBean, mbd);
    }
    catch (Throwable ex) {
        throw new BeanCreationException(
            (mbd != null ? mbd.getResourceDescription() : null),
            beanName, "Invocation of init method failed", ex);
    }
    if (mbd == null || !mbd.isSynthetic()) {
        //初始化后应用Bean后处理器
        wrappedBean = applyBeanPostProcessorsAfterInitialization(wrappedBean,
beanName);
    }

    return wrappedBean;
}

//初始化
protected void invokeInitMethods(String beanName, Object bean, @Nullable
RootBeanDefinition mbd)
            throws Throwable {

    boolean isInitializingBean = (bean instanceof InitializingBean);
    if (isInitializingBean && (mbd == null ||
!mbd.isExternallyManagedInitMethod("afterPropertiesSet"))) {
        if (logger.isTraceEnabled()) {
            logger.trace("Invoking afterPropertiesSet() on bean with name '" +
beanName + "'");
        }
        if (System.getSecurityManager() != null) {
            try {

 AccessController.doPrivileged((PrivilegedExceptionAction<Object>) () -> {
                    ((InitializingBean) bean).afterPropertiesSet();
                    return null;
                }, getAccessControlContext());
            }
            catch (PrivilegedActionException pae) {
                throw pae.getException();
            }
```

```
        }
        else {
            //初始化（实现InitializingBean接口）
            ((InitializingBean) bean).afterPropertiesSet();
        }
    }

    if (mbd != null && bean.getClass() != NullBean.class) {
        String initMethodName = mbd.getInitMethodName();
        if (StringUtils.hasLength(initMethodName) &&
            !(isInitializingBean && "afterPropertiesSet".equals(initMethodName))
&&
            !mbd.isExternallyManagedInitMethod(initMethodName)) {
            invokeCustomInitMethod(beanName, bean, mbd);
        }
    }
}
```

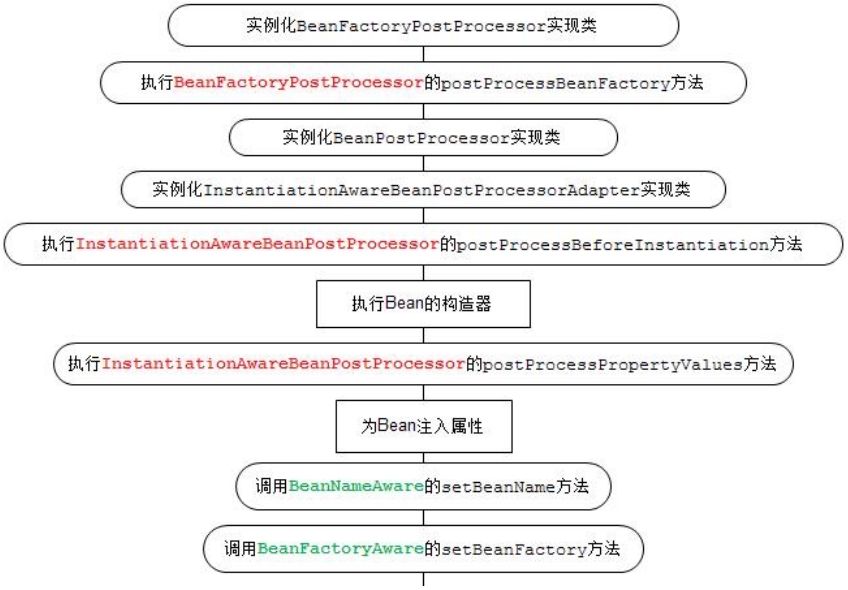
12、完成刷新过程

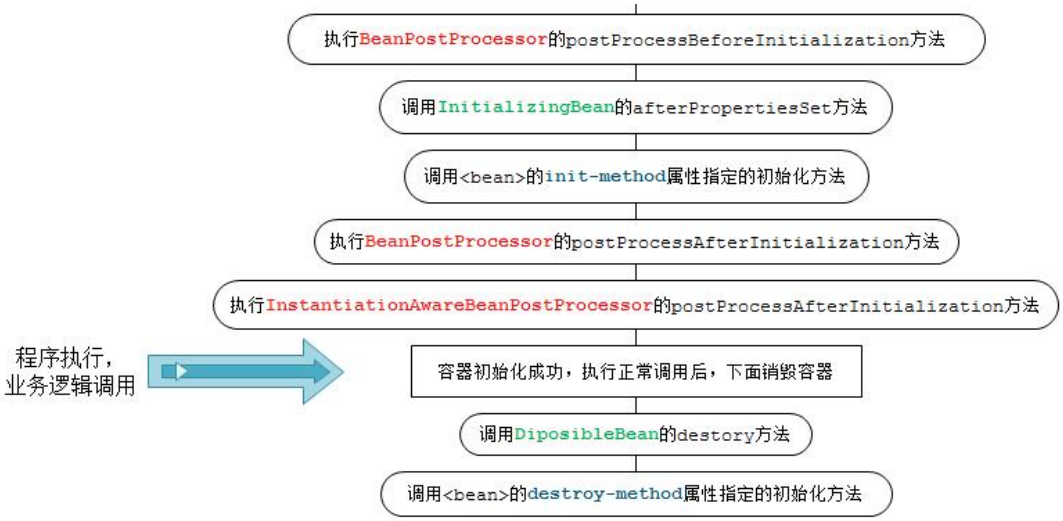
```
/ 12、Last step: publish corresponding event.，通知生命周期处理器lifecycleProcessor刷新过程，同时发出ContextRefreshEvent通知相关事件
finishRefresh();
```

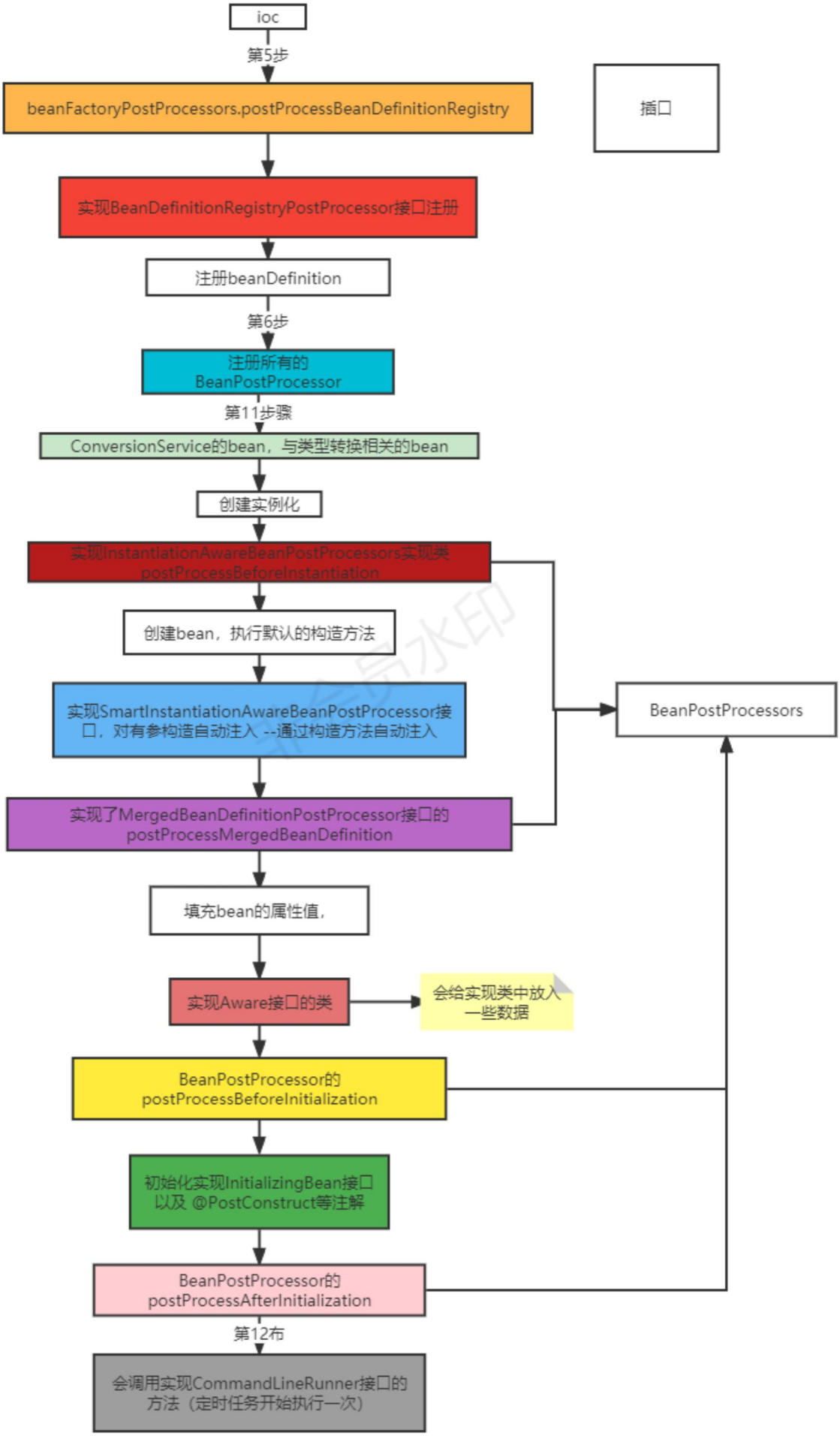
2、获取bean

```
MyBean myBean = context.getBean(MyBean.class);

return getBeanFactory().getBean(requiredType);
会调用到创建bean中
```




执行BeanPostProcessor的postProcessBeforeInitialization方法
调用InitializingBean的afterPropertiesSet方法
调用<bean>的init-method属性指定的初始化方法
执行BeanPostProcessor的postProcessAfterInitialization方法
执行InstantiationAwareBeanPostProcessor的postProcessAfterInitialization方法
程序执行，
业务逻辑调用
容器初始化成功，执行正常调用后，下面销毁容器
调用DiposibleBean的destory方法
调用<bean>的destroy-method属性指定的初始化方法


ioc
第5步
beanFactoryPostProcessors.postProcessBeanDefinitionRegistry
插口
实现BeanDefinitionRegistryPostProcessor接口注册
注册beanDefinition
第6步
注册所有的
BeanPostProcessor
第11步骤
ConversionService的bean，与类型转换相关的bean
创建实例化
实现InstantiationAwareBeanPostProcessors实现类
postProcessBeforeInstantiation
创建bean，执行默认的构造方法
实现SmartInstantiationAwareBeanPostProcessor接
口，对有参构造自动注入 --通过构造方法自动注入
BeanPostProcessors
实现了MergedBeanDefinitionPostProcessor接口的
postProcessMergedBeanDefinition
填充bean的属性值，
实现Aware接口的类
会给实现类中放入
一些数据
BeanPostProcessor的
postProcessBeforeInitialization
初始化实现InitializingBean接口
以及 @PostConstruct等注解
BeanPostProcessor的
postProcessAfterInitialization
第12布
会调用实现CommandLineRunner接口的
方法（定时任务开始执行一次）