Spring Framework
Inversion of control

Part 1

Spring Framework - Introduction

- Spring is a **lightweight** yet at the same time **flexible** and **universal** framework used for creating Java SE and Java EE applications
- Spring is a framework with an **open source code**
- Spring is an **application framework**, not a layer framework
- Spring includes several separate frameworks

Spring Framework - Introduction

- **Rod Johnson** created Spring in **2003**
- Spring took its rise from books ***Expert One-on-One Java J2EE Design and Development*** and ***J2EE Development Without EJB***
- The basic idea behind Spring is to **simplify** the traditional approach to designing J2EE applications

Rod Johnson

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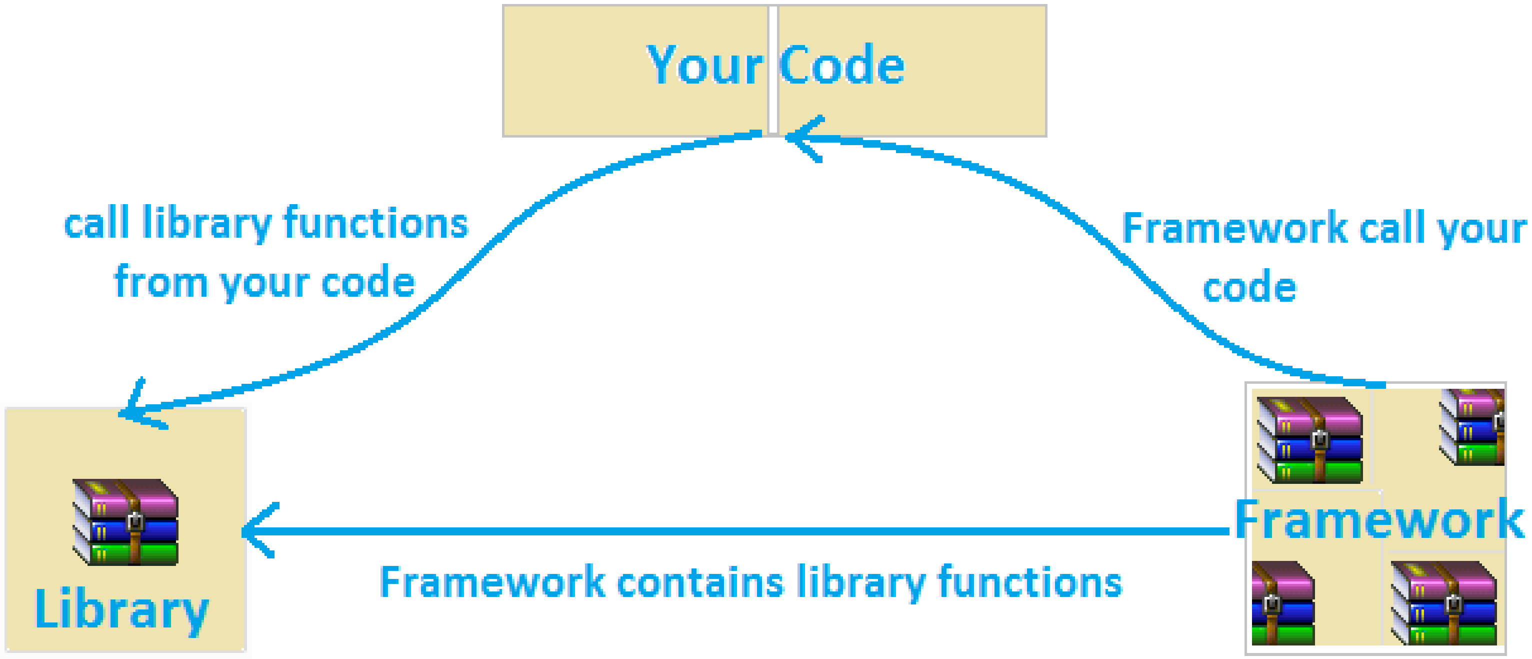
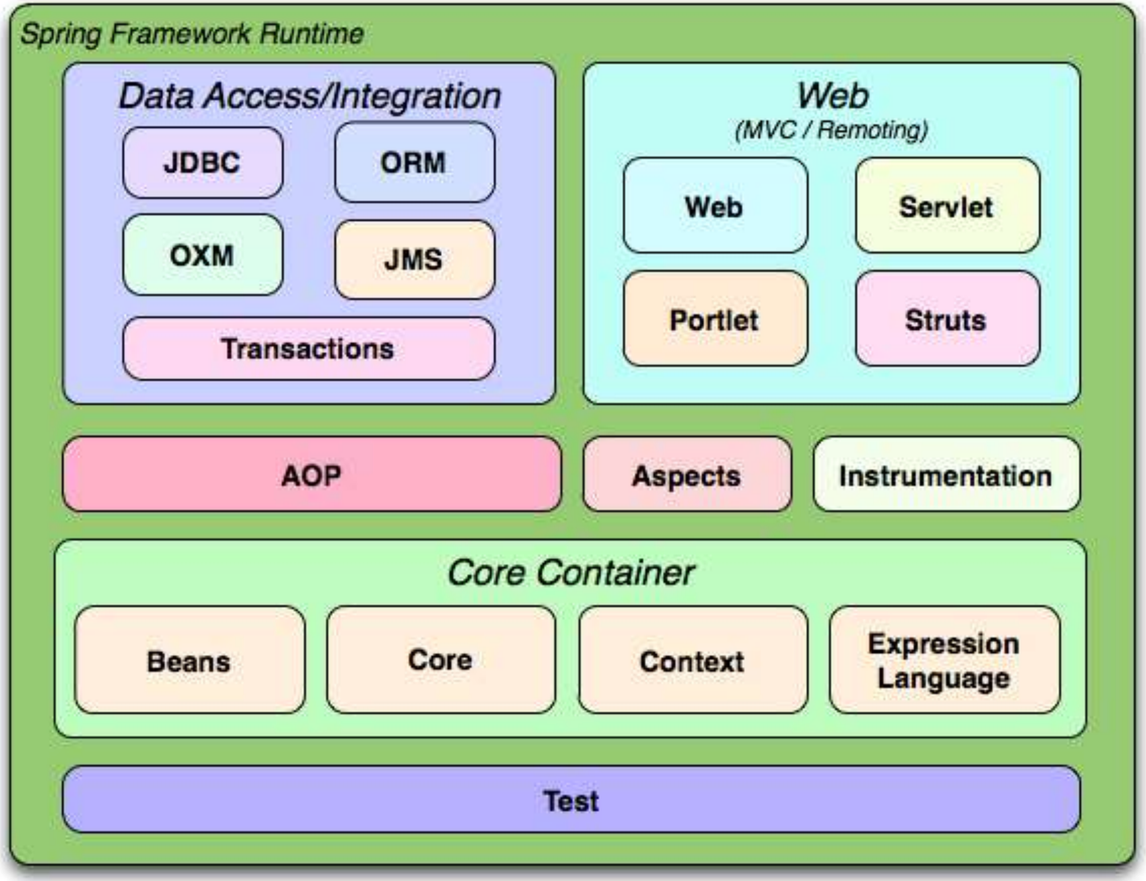
expert one-on-one

J2EE™ Design and Development

Differences between Library and Framework


Your Code
call library functions from your code
Framework call your code
Library
Framework
Framework contains library functions

Spring Framework - Core Container



Core Container consists of:

- spring-beans
- spring-core
- spring-context
- spring-context-support
- spring-expression

Spring Framework - Framework structure

- **Spring Framework** - **Java platform** that provides comprehensive infrastructure for developing Java applications
- Handles the infrastructure so you can focus on your application
- Enables you to build applications from **"plain old Java objects" (POJOs)** and to apply enterprise services to **POJOs**

Spring Framework – Object dependencies

- Spring implements various design patterns:

  - **Factory**
  - **Builder**
  - **Proxy**

- The Spring Framework **Inversion of Control (IoC)** provides a means of composing disparate components into a fully working application.

Spring Framework – Object Dependencies

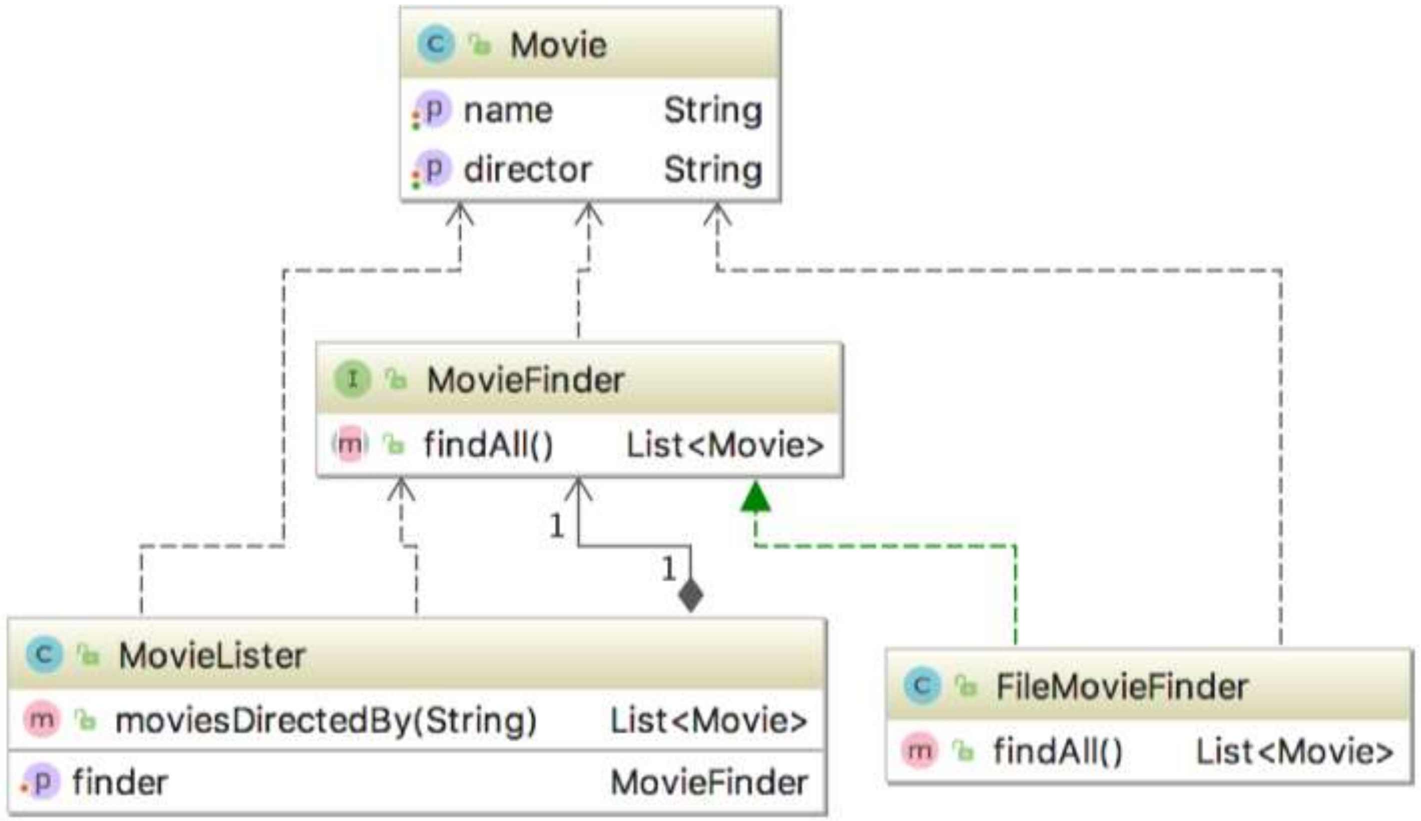
```java
public class DirectMovieLister
{
    private FileMovieFinder finder;

    public DirectMovieLister()
    {
        finder = new FileMovieFinder();
    }

    public List<Movie> moviesDirectedBy(String director)
    {
        List<Movie> result = new ArrayList<>();

        for (Movie movie : finder.findAll())
        {
            if (movie.getDirector().equals(director))
            {
                result.add(movie);
            }
        }
        return result;
    }
}
```

Spring Framework – Object Dependencies

What if:

- You have a completely different form of storing a movie listing: XML file, SLQ database, http service, etc?
- I need to test **DirectMovieLister** separately from **FileMovieFinder**?

Spring Framework – Object Dependencies



Spring Framework – Object Dependencies

In this case we can:

- Use different implementations of **FileMovieFinder** in different deployments
- Change implementations at runtime
- Use single instance of **FileMovieFinder** for several instances of **MovieLister**

Spring Framework – Object Dependencies

So the core problem is:

How do we assemble these services into an application?

Spring Framework – Object dependencies

We have to automate this:

```
public static void main(String[] args)
{
      MovieFinder finder = new FileMovieFinder();

      MovieLister lister = new MovieLister();

      lister.setFinder(finder);

      List<Movie> filtered = lister.moviesDirectedBy("Spielberg");
}
```

And we need a Dependency Injection Framework to do it for us!

Spring Framework – Object dependencies

1. Object **defines** dependencies via configuration
2. The **container then injects** those dependencies **when it creates** a specific object

Spring Framework – Object Dependencies

Inversion of Control Container approach

application-context.xml

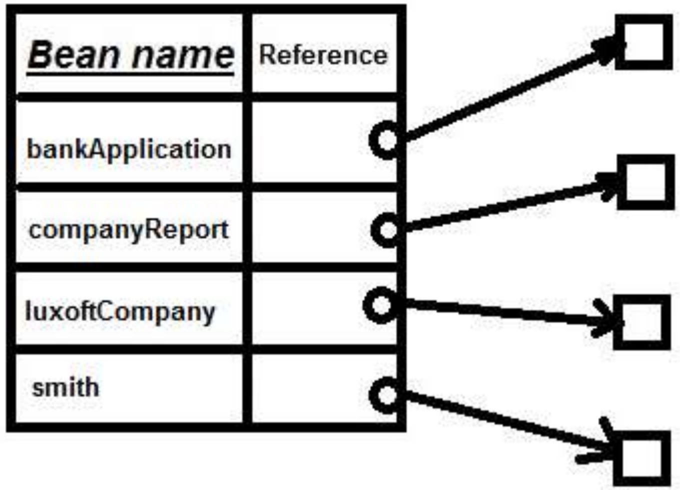
```
<bean id="fileMovieFinder" class="com.luxoft.springioc.movies.FileMovieFinder">
     <property name="fileName" value="movies.txt" />
</bean>

<bean id="movieLister" class="com.luxoft.springioc.movies.MovieLister">
     <property name="finder" ref="fileMovieFinder" />
</bean>
```

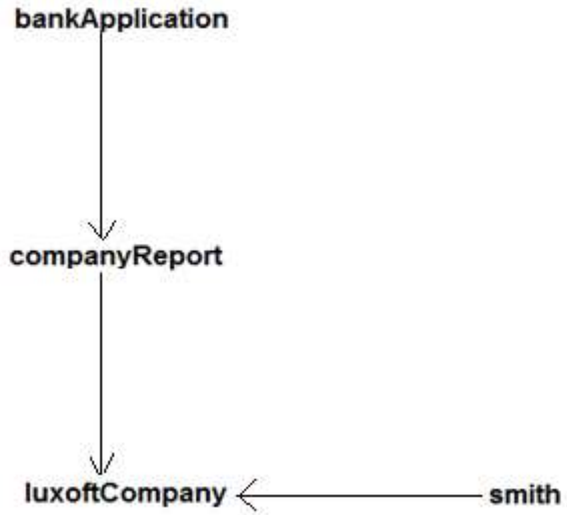
```
public static void main(String[] args)
{
     ClassPathXmlApplicationContext context =
           new ClassPathXmlApplicationContext("movies/application-context.xml");

      MovieLister lister = (MovieLister) context.getBean("movieLister");
      List<Movie> filtered = lister.moviesDirectedBy("Spielberg");
}
```

ex. movies

Internal Structure of Application Context

- The application context internally keeps a map to provide access to the managed objects. The creation of the objects and their relationship is managed by the container through IoC/DI.





Spring Framework – Object Dependencies

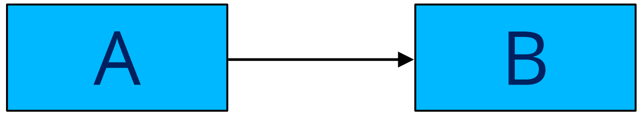
Inversion of Control Container approach

Advantages:

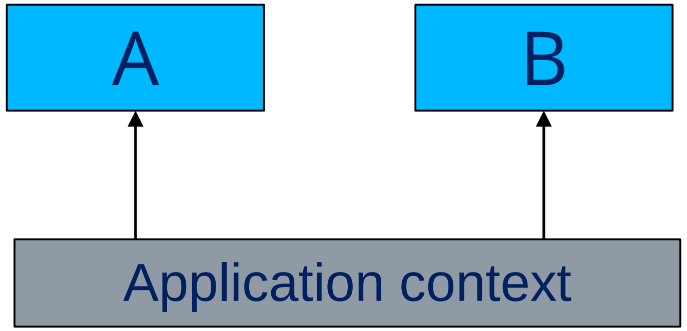
- The container creates the necessary objects and manages their lifetime
- **MovieLister** and **FileMovieFinder** are independent objects
- Application Context creates beans and injects configured dependencies
- It’s very easy to make changes to object dependencies in the system

Spring Framework – Object Dependencies

Traditional approach: dependencies inside the code



IoC: objects know nothing about each other



- *Creates B and initializes it*
- *Creates A and initializes it*
- *Injects B to A*

Spring Framework – IoC / DI

Inversion of Control (IoC) or Dependency Injection (DI) pattern is the base for Spring.

- The “Hollywood Principle” – Don't call me, I'll call you

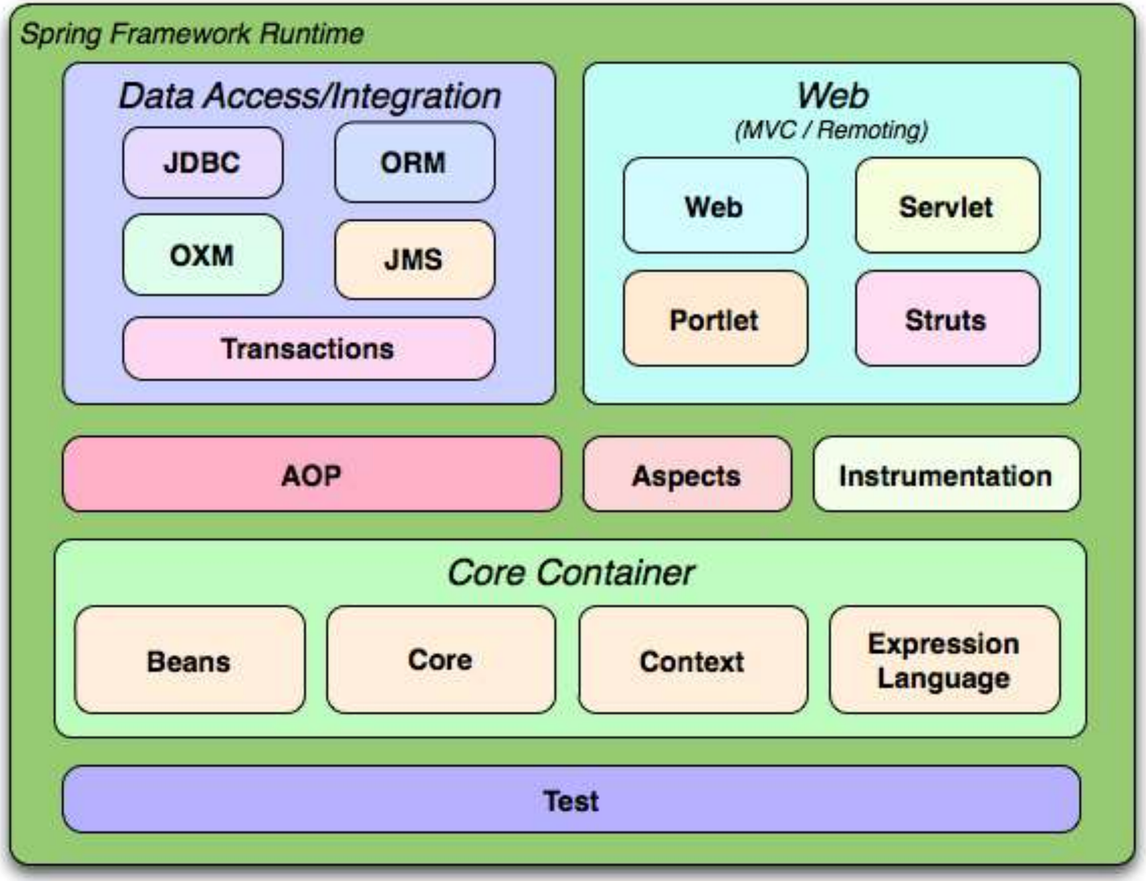
- The basic idea is to eliminate the dependency of application components from certain implementation and to delegate DI container rights to control classes instantiation and initialization

Spring Framework – IoC / DI

Advantages of IoC containers:

- Dependency management and applying changes without recompiling
- Facilitates reusing classes or components
- Simplified unit testing
- Cleaner code (classes do not initiate auxiliary objects)
- It is especially recommended to insert the objects for which the implementation may change to the DI container

Spring Framework - Core Container



Core Container consists of:

- spring-beans
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- spring-expression

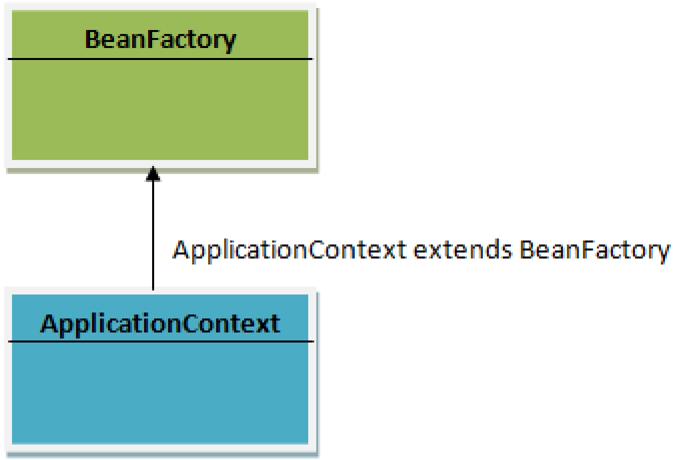
Spring Framework – IoC containers

- The ***BeanFactory*** is a central **IoC** container interface into the **Spring Framework**
- Implementation of the factory pattern
- Most common implementation: ***XmlBeanFactory***
- ***BeanFactory*** provides only basic low-level functionality

Spring Framework – IoC Containers

- **`ApplicationContext extends BeanFactory`** and adds:
  - Event handling
  - Internationalization
  - Work with resources and messages
  - Simple integration with Spring AOP
  - Specific application contexts

  (for example, ***ClassPathXmlApplicationContext***)



Spring Framework – IoC Containers

- The **ApplicationContext** interface is the focal point of the **Context** module
- **ApplicationContext**s are used in real life
- **BeanFactory** could be used in exceptional cases:
    - Integrating Spring with a framework (backward compatibility is necessary)
    - Resources are critical and only IoC container is required

Spring Framework – IoC containers

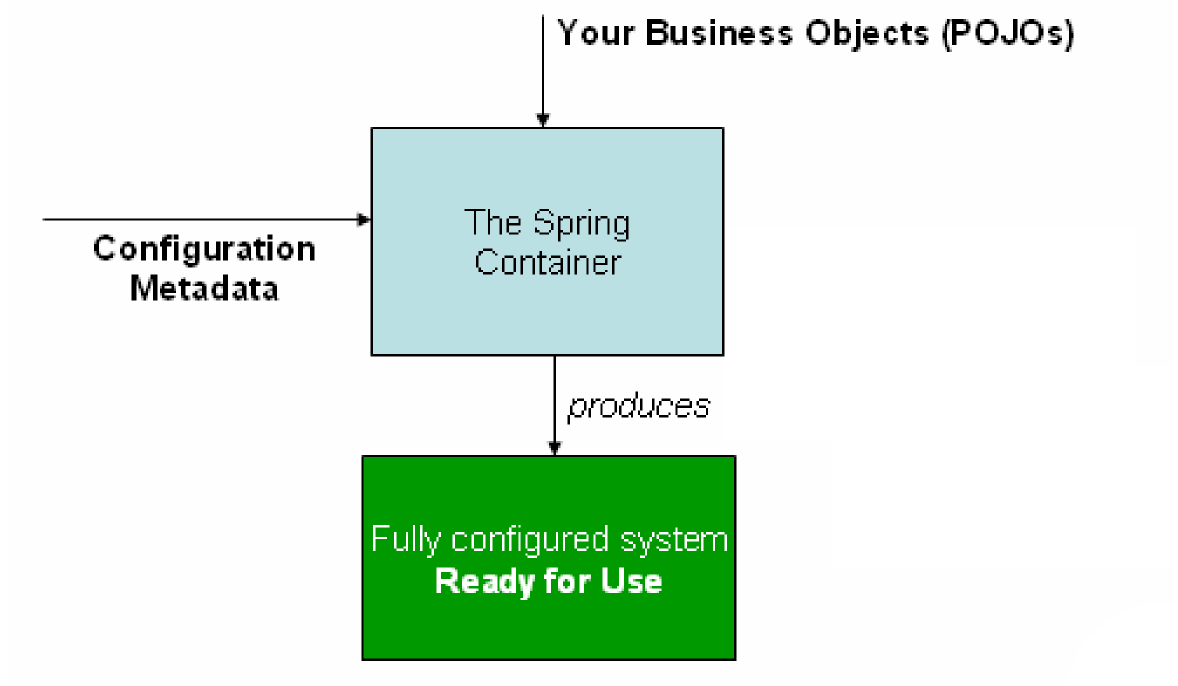
- Most widely used implementations of **ApplicationContext**:
  - **GenericXmlApplicationContext** (since v.3.0)
  - **ClassPathXmlApplicationContext**
  - **FileSystemXmlApplicationContext**
- XML is a traditional way to configure a container
- It is easier and faster to use annotation-based configuration, but this one has some restrictions and introduces additional code-level dependencies

Spring Framework – IoC Containers

```
ApplicationContext context =
   new GenericXmlApplicationContext("classpath:context.xml");

ApplicationContext context =
   new ClassPathXmlApplicationContext("context.xml");


ApplicationContext context =
   new GenericXmlApplicationContext("context.xml");

ApplicationContext context =
   new FileSystemXmlApplicationContext("context.xml");
```

Spring Framework – IoC Containers

In general, the work of a Spring IoC container can be represented as follows:



Spring Framework – Maven Configuration

```xml
<dependency>
  <groupId>org.springframework</groupId>
  <artifactId>spring-context</artifactId>
  <version>5.1.3.RELEASE</version>
</dependency>
```

Spring Framework – Working with IoC Container

Container creation:

```
ApplicationContext context =
    new ClassPathXmlApplicationContext("application-context.xml");

MovieLister lister = (MovieLister) context.getBean(“movieLister");

Ex1TestBean testBean = context.getBean(Ex1TestBean.class);
```

ex.1

Spring Framework – Working with IoC Container

```
ApplicationContext context = new ClassPathXmlApplicationContext(
     new String[]{"example02/services.xml", "example02/daos.xml"});

Service service = context.getBean(ServiceBean.class);
service.printNames();
```

services.xml

```
<bean id="service" class="com.luxoft.springioc.example02.ServiceBean" >
     <property name="dao" ref="dao" />
</bean>
```

daos.xml

```
<bean id="dao" class="com.luxoft.springioc.example02.DaoBean"/>
```

ex. 2

Spring Framework – Bean Creation

no-args constructor:

```
<bean id="clientService" class="com.luxoft.springioc.ClientService"/>
```

ex.3

Spring Framework – Bean Creation

Factory method:

```
<bean id="clientService" class="com.luxoft.springioc.ClientService"
                        factory-method="createInstance" >
    < constructor-arg value="Software Development" />
</bean>

public static ClientService createInstance(String serviceType ) {
    ClientService clientService = new ClientService();
    clientService.setServiceType(serviceType);
    if (serviceType.equals("Software Development")) {
        clientService.setRemote(true);
    }
    // possibly perform some other operations
    // with clientService instance
    return clientService;
}
```

ex. 4

Task for ex. 4

Create `BusinessService` which will be retrieved by a factory method. A `BusinessService` is defined by company name and by domain. If company name is `"Luxoft"`, domain will be `"IT"`. Otherwise, domain will be `"Financial"`.

Spring Framework – Bean Creation

Factory class:

```
<bean id="serviceFactory" class="com.luxoft.springioc.DefaultServiceFactory"/>
<bean id="clientService" factory-bean="serviceFactory"
    factory-method="createClientServiceInstance" >
        <constructor-arg value="Retailing" />
</bean>

public ClientService createClientServiceInstance(String serviceType) {
    ClientService clientService = new ClientService();
    clientService.setServiceType(serviceType);
    if (serviceType.equals("Software Development")) {
        clientService.setRemote(true);
    }
    return clientService;
}
```

ex.5

Task for ex. 5

- Use BusinessService to be retrieved by DefaultServiceFactory

Spring Framework – Lazy Initialization

Lazy initialization is used to postpone bean creation until it is first addressed.

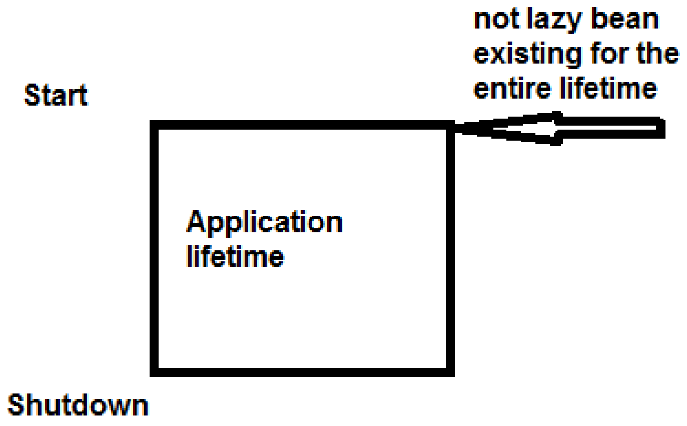
Lazy initialization of single bean:

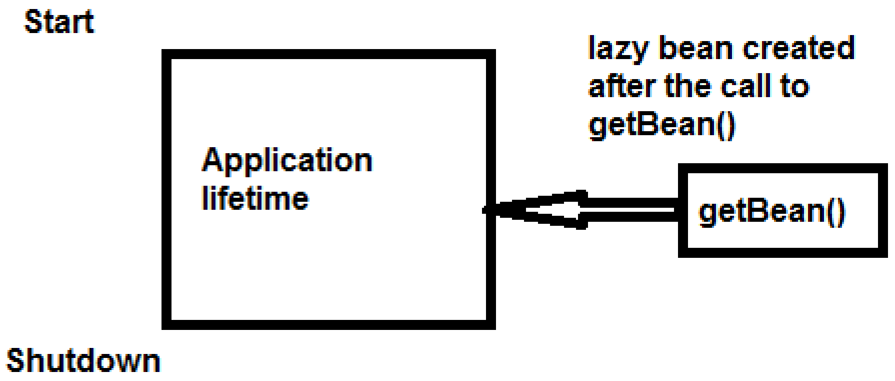
```
<bean id="bean1" class="Bean1"/>
<bean id="bean2" class="Bean2" lazy-init="false"/>
<bean id="bean3" class="Bean3" lazy-init="default"/>
<bean id="bean4" class="Bean4" lazy-init="true"/>
```

Lazy initialization of all beans in a container:

```
<beans default-lazy-init="true">
   ...
</beans>
```

Lazy and Not Lazy Beans Lifetime





Task: change the XML configuration to use lazy initialization for all beans, by default.

ex.6

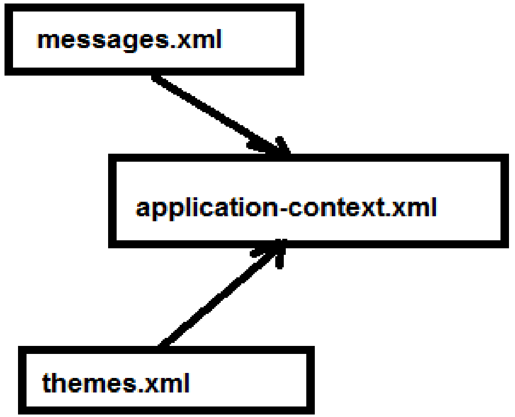
Spring Framework – Context Import

It’s often convenient to break the context into several files:

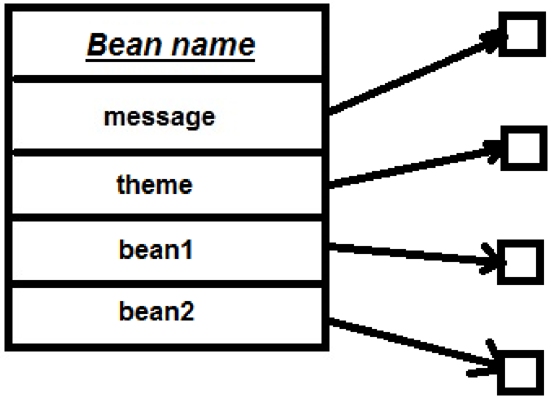
```
<beans>
   <import resource="messages.xml"/>
   <import resource="themes.xml"/>

   <bean id="bean1" class="com.luxoft.springioc.example07.Bean1"/>
   <bean id="bean2" class="com.luxoft.springioc.example07.Bean2"/>
</beans>
```

Spring Framework – Context Import

Context import functionality:



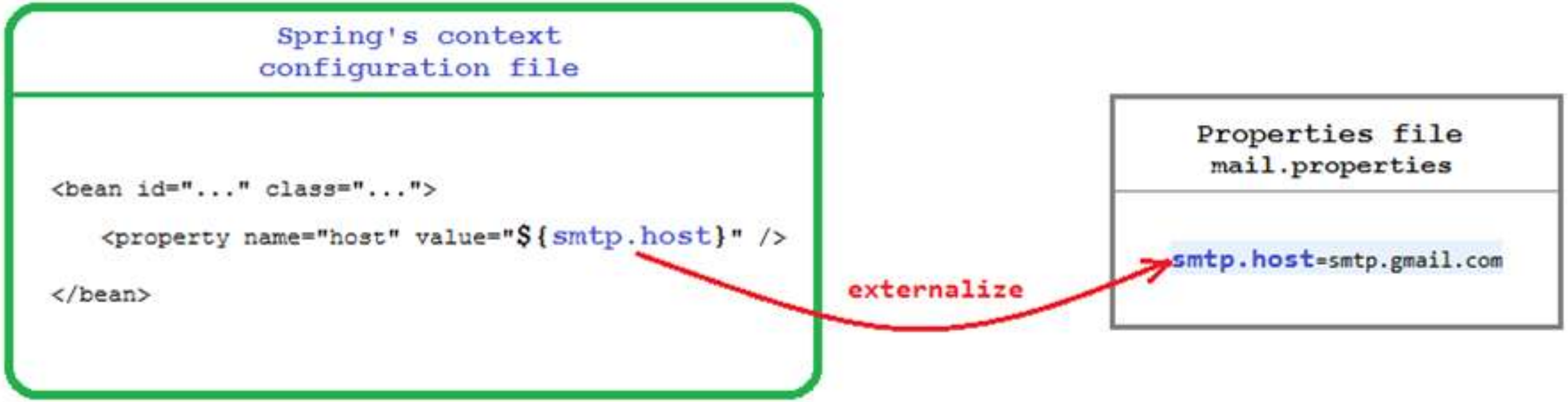
Context content:



ex.7

Spring Framework – Use of Property Files with Context

- Spring allows to externalize literals in its context configuration files into external properties
- In Spring, context configuration files use placeholders: `${variable_name}`
- Spring reads properties files declared by `PropertyPlaceholderConfigurer` bean



```
<bean id="..." class="...">
    <property name="host" value="${smtp.host}" />
</bean>
```

```
smtp.host=smtp.gmail.com
```

Spring Framework – Use of Property Files with Context

- By default, Spring looks for the properties files in the application’s directory

```
<property name="location" value="WEB-INF/jdbc.properties" />
```

It will find the jdbc.properties file under WEB-INF directory of the application (in case of a Spring MVC application)

- We can use the prefix `classpath:` to tell Spring to load a properties file in the application’s `classpath`

```
<property name="location" value="classpath:jdbc.properties" />
```

- Use the prefix `file:///` or `file:` to load a properties file from an absolute path

```
<property name="location" value="file:///D:/Config/jdbc.properties" />
```

Spring Framework – Use of Property Files with Context

```xml
<bean class="PropertyPlaceholderConfigurer">
   <property name="locations" value="classpath:example08/jdbc.properties"/>
</bean>

<bean id="dataSource" class="com.luxoft.springioc.example08.DataSource">
   <property name="driverClassName" value="${jdbc.driverClassName}" />
   <property name="url" value="${jdbc.url}" />
   <property name="username" value="${jdbc.username}" />
   <property name="password" value="${jdbc.password}" />
</bean>
```

jdbc.properties:

```
jdbc.driverClassName=org.hsqldb.jdbcDriver
jdbc.url=jdbc:hsqldb:hsql://production:9002
jdbc.username=sa
jdbc.password=password
```

ex.8

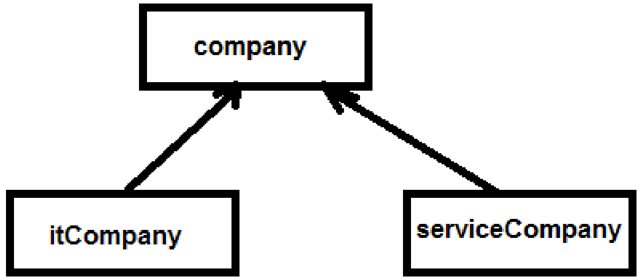
Spring Framework – Use of Alias

The bean named **originalName** may be referred as **aliasName**

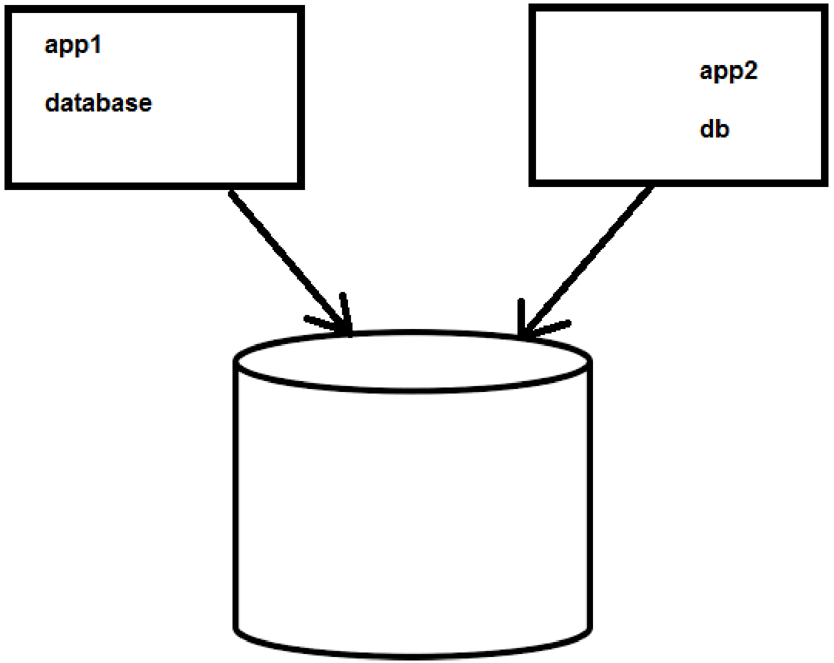
It is used to provide future bean specialization. For example, we may refer beans as **serviceCompany** and **itCompany**, but for a while we have no special implementation for it, we use aliases:

```
<bean id="company" class="com.luxoft.springioc.example09.Company"/>

<alias name="company" alias="itCompany"/>
<alias name="company" alias="serviceCompany"/>
```

Spring Framework – Use Cases for Alias



Bean specialization



Override bean definitions inherited from external sources

ex.9

Spring Framework – Constructor Dependency Injection

Dependency injection with use of constructor with arguments:

```java
public class Company {
    private String name;

    public Company(String name) {
        this.name = name;
    }
    …
}
```

```java
public class Person {
    private String name;
    private Company company;

    public Person(String name, Company company) {
        this.name = name;
        this.company = company;
    }
    …
}
```

Spring Framework – Constructor Dependency Injection

```
<bean id="luxoftCompany" class="com.luxoft.springioc.example10.Company" >
      <constructor-arg value="Luxoft" />
</bean>

<bean id="smithPerson" class="com.luxoft.springioc.example10.Person">
     <constructor-arg value="John Smith" />
      <constructor-arg ref="luxoftCompany" />
</bean>
```

ex.10

Spring Framework – Constructor Dependency Injection

Cyclic dependency:

```
public class A {
   private B b;

   public A(B b) {
     this.b = b;
   }

}
```

```
public class B {
   private A a;

   public B(A a) {
     this.a = a;
   }

}
```

We will get ***BeanCurrentlyInCreationException*** during Dependency Injection
Solution: to replace Constructor Dependency Injection with Setter Dependency Injection in one or both classes

ex.11_error

Replace Constructor Injection with Setter Injection

```java
public class A {
   private B b;

   public B getB() {
     return b;
   }

   public void setB(B b) {
     this.b = b;
  }
}
```

```java
public class B {
    private A a;

    public A getA() {
        return a;
    }

    public void setA(A a) {
        this.a = a;
    }
}
```

```xml
<bean id="a" class="com.luxoft.springioc.example11_correct.A">
    <property name = "b" ref="b"/>
</bean>
<bean id="b" class="com.luxoft.springioc.example11_correct.B">
    <property name = "a" ref="a"/>
</bean>
```

ex. 11_correct

Spring Framework – Setter Dependency Injection

```java
public class Person {
    private Company company;
    private String name;
    ...

    public void setCompany(Company company) {
       this.company = company;
    }
}
```

```xml
<bean id="luxoftCompany" class="com.luxoft.springioc.example12.Company" >
   <property name="name" value="Luxoft" />
</bean>

<bean id="smithPerson" class="com.luxoft.springioc.example12.Person">
    <property name="name" value="John Smith" />
    <property name="company" ref="luxoftCompany" />
</bean>
```

ex.12

Spring Framework – Autowiring

Spring is able to resolve and add dependencies automatically

```
<bean id="..." class="..." autowire="no|byName|byType|constructor" />
```

- Can cause configuration to keep itself up to date
- It can significantly reduce the volume of configuration

- Autowiring by type can only work if application context contains exactly one bean of a property type
- It is harder to read and check dependencies

Spring Framework – Autowiring

Autowiring modes:

– **no**: no autowiring. This is the default

– **byName**: container looks for a bean with ID exactly the same as the property which needs to be autowired. If such a bean cannot be found, the object is not autowired

– **byType**: container looks for a bean of specific class, works only if there is exactly one bean of property type in container otherwise **UnsatisfiedDependencyException** is thrown

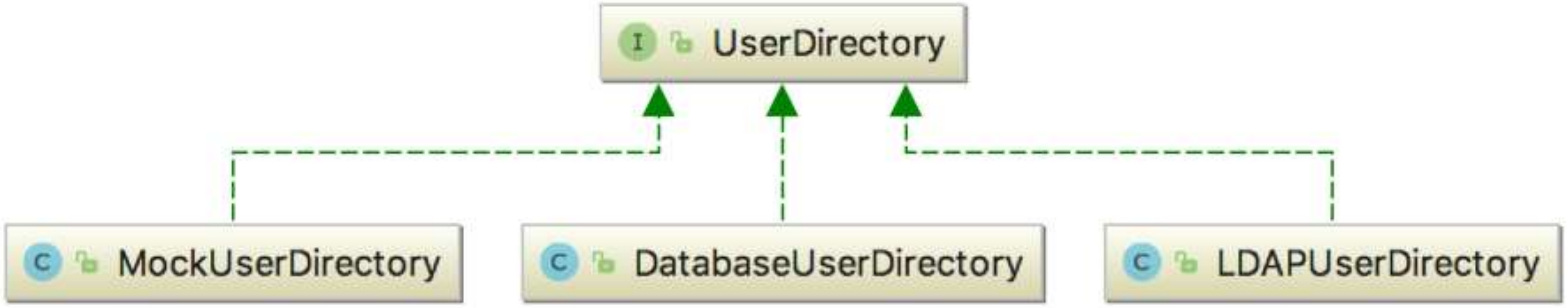
– **constructor**: will create object using constructor and use **byType** autowiring to find arguments

Spring Framework – Autowiring

If there is more than one bean of a given type and we try to autowire byType, we are getting an error like the following:

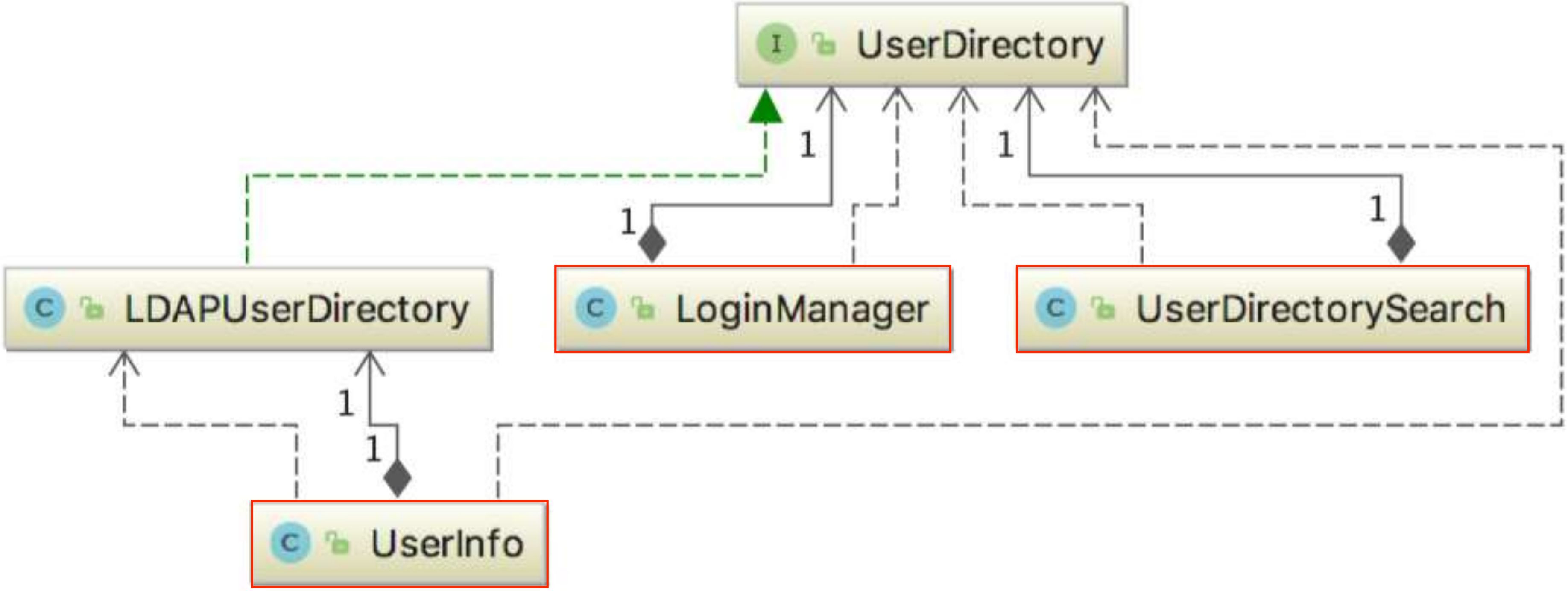
```
Exception in thread "main"
org.springframework.beans.factory.UnsatisfiedDependencyException: Error creating bean
with name 'userInfo' defined in class path resource [example14/application-context.xml]:
Unsatisfied dependency expressed through bean property 'userDirectory':

No qualifying bean of type [com.luxoft.springioc.example14.UserDirectory] is defined:
expected single matching bean but found 2: userDirectory,userDirectory2;

nested exception is org.springframework.beans.factory.NoUniqueBeanDefinitionException:
No qualifying bean of type [com.luxoft.springioc.example14.UserDirectory] is defined:
expected single matching bean but found 2: userDirectory,userDirectory2
```

Spring Framework – Autowiring



ex.13

Spring Framework – Autowiring



ex.13

Spring Framework – Autowiring

Let’s have classes which need the information about the user:

```
<bean id="userDirectory" class="com.luxoft.springioc.example13.LDAPUserDirectory" />

<bean id="loginManager" class="com.luxoft.springioc.example13.LoginManager">
   <property name="userDirectory" ref="userDirectory" />
</bean>

<bean id="userDirectorySearch" class="com.luxoft.springioc.example13.UserDirectorySearch">
   <property name="userDirectory" ref="userDirectory" />
</bean>

<bean id="userInfo" class="com.luxoft.springioc.example13.UserInfo">
   <property name=“ldapUserDirectory" ref="userDirectory" />
</bean>
```

ex.13

Spring Framework – Autowiring

Now let’s turn on the autowiring:

```
public class LoginManager {
   private UserDirectory userDirectory;
}

public class UserDirectorySearch {
   private UserDirectory userDirectory;
}

public class UserInfo {
   private LDAPUserDirectory
           ldapUserDirectory;
}
```

```
<bean id="userDirectory"
      class="LDAPUserDirectory" />


<bean id="loginManager" class="LoginManager"
      autowire="byName" />


<bean id="userDirectorySearch"
      class="UserDirectorySearch"
      autowire="byName" />


<bean id="userInfo"
      class="UserInfo"
      autowire="byType" />
```

ex.14

Tasks for ex. 13 and 14

- Change example 13 so that it is using autowiring
- Change example 14 so that the **`userInfo`** bean has autowiring **`byName`** instead of **`byType`**; explain the difference in execution
- Change example 14 so that the **`UserInfo`** class contains a **`UserDirectory`** type field instead of **`LDAPUserDirectory`**; execute the program and note that autowiring is permitted also for classes that are descendants of a given class

Spring Framework – Collections Initialization

```java
public class Customer {
    private List<Object> list;
    …
}
```

```xml
<bean id="customerBean" class="com.luxoft.springioc.example15.Customer">
    <!-- java.util.List -->
    <property name="list">
        <list>
            <value>1</value>
            <ref bean="personBean" />
            <bean class="com.luxoft.springioc.example15.Person">
                <property name="name" value="John" />
                <property name="address" value="address" />
                <property name="age" value="28" />
            </bean>
        </list>
    </property>
```

Spring Framework – Collections Initialization

```
public class Customer {
    …
    private Set<Object> set;
}

    <!-- java.util.Set -->
    <property name="set">
        <set>
            <value>1</value>
            <ref bean="personBean" />
            <bean class="com.luxoft.springioc.example15.Person">
                <property name="name" value="John" />
                <property name="address" value="address" />
                <property name="age" value="28" />
            </bean>
        </set>
    </property>
```

Spring Framework – Collections Initialization

```
public class Customer {
    …
    private Map<Object, Object> map;
}

    <!-- java.util.Map -->
    <property name="map">
        <map>
            <entry key="Key 1" value="1" />
            <entry key="Key 2" value-ref="personBean"/>
            <entry key="Key 3">
                <bean class="com.luxoft.springioc.example15.Person">
                   <property name="name" value="John" />
                   <property name="address" value="address" />
                   <property name="age" value="28" />
                </bean>
            </entry>
        </map>
    </property>
```

Spring Framework – Collections Initialization

The same as:

```
Customer customerBean = (Customer)context.getBean("customerBean");
customerBean.getMap().put("Key 1", "1");
customerBean.getMap().put("Key 2", context.getBean("personBean");


Person person = new Person();
person.setName("John");
person.setAddress("address");
person.setAge(28);
customerBean.getMap().put("Key 3", person);
```

Spring Framework – Collections Initialization

```java
public class Customer {
    …
    private Map<String, Object> stringsMap;
    …
}
```

```xml
<!-- java.util.Map -->
<property name="stringsMap">
    <map>
        <entry key="String key 1" value="1" />
        <entry key="String key 2" value-ref="personBean"/>
    </map>
</property>
```

Spring Framework – Collections Initialization

```
public class Customer {
    …
    private Map<Person, String> personsMap;
    …
}

<!-- java.util.Map -->
<property name="personsMap">
    <map>
        <entry key-ref="personBean" value="USA" />
    </map>
</property>
```

Spring Framework – Collections Initialization

```java
public class Customer {
    …
    private Properties props;
}
```

```xml
    <!-- java.util.Properties -->
    <property name="props">
        <props>
            <prop key="admin">admin@example.com</prop>
            <prop key="support">support@example.com</prop>
        </props>
    </property>
```

ex.15

Spring Framework – Properties Inheritance

```
<bean id="testBean"
      abstract="true" class="com.luxoft.springioc.example16.TestBean">
    <property name="name" value="parent" />
    <property name="age" value="1" />
</bean>


<bean id="inheritsWithDifferentClass"
      class="com.luxoft.springioc.example16.DerivedTestBean" parent="testBean">
    <property name="name" value="override" />
    <!-- the age property value of 1 will be inherited from parent -->
</bean>
```

ex.16

Task for ex. 16

- Change example 16 so that the parent class is no longer **`abstract`**; make sure that you make the modifications both at the level of the class and configuration

Spring Framework – Merge of Collections

```
<bean id="parent" abstract="true" class="ComplexObject">
    <property name="adminEmails">
        <props>
            <prop key="administrator">administrator@example.com</prop>
            <prop key="support">support@example.com</prop>
        </props>
    </property>
</bean>
<bean id="child" parent="parent">
    <property name="adminEmails">
    <!-- the merge is specified on the *child* collection definition -->
        <props merge="true">
            <prop key="sales">sales@example.com</prop>
            <prop key="support">support@example.co.uk</prop>
        </props>
    </property>
</bean>
```

```
administrator=administrator@example.com
sales=sales@example.com
support=support@example.co.uk
```

ex.17

Applicable to properties, list, set, map.

Spring Framework – Empty and Null Properties

```xml
<bean id="exampleBean"
      class="com.luxoft.springioc.example18.ExampleBean">
   <property name="name" value="" />
   <property name="email"><null/></property>
</bean>
```

ex.18

Spring Framework – p-namespace

```
<bean id="classic" class="com.luxoft.springioc.example19.ExampleBean">
   <property name="email" value="foo@bar.com" />
</bean>

<bean id="p-namespace" class="com.luxoft.springioc.example19.ExampleBean"
                         p:email="foo@bar.com" />

<bean id="john-classic" class="com.luxoft.springioc.example19.Person">
   <property name="name" value="John Doe" />
   <property name="spouse" ref="jane" />
</bean>

<bean id="john-modern" class="com.luxoft.springioc.example19.Person"
      p:name="John Doe“ p:spouse-ref="jane" />

<bean id="jane" class="com.luxoft.springioc.example19.Person">
   <property name="name" value="Jane Doe" />
</bean>
```

ex.19

Exercise

Lab guide:

- Exercise 1