

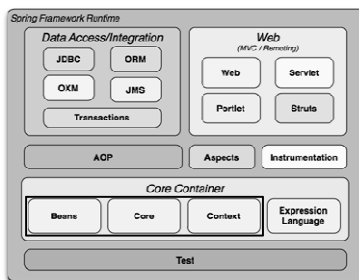
## CS520 Web Programming Spring – Inversion of Control

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## Background

- ◆ Originally developed by Rod Johnson
- ◆ Addresses many problems of EJB
- ◆ One of the most popular Java web development frameworks
- ◆ Books
  - *Expert One-on-One: J2EE Design and Development (2002)*
  - *Expert One-on-One: J2EE Development without EJB (2004)*
  - *Professional Java Development with the Spring Framework (2005)*

## Spring Framework

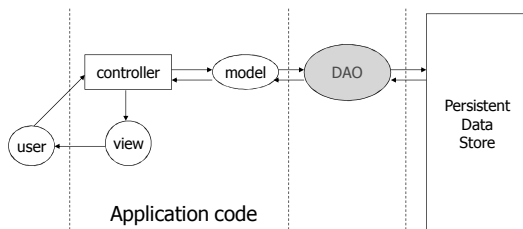


## The Need for IoC

- ◆ The DAO Example
  - The Data Access Object (DAO) pattern
  - UserDao Example
    - ◆ Interface
    - ◆ Implementation
    - ◆ Usage in application code

## Data Access Object (DAO)

- ◆ A Java EE design pattern



## DAO Interface

```
public interface UserDao {  
  
    User getUserById( Integer id );  
  
    List getAllUsers();  
  
}
```

## DAO Implementation

### ◆ Implement UserDao using JPA

```
public class UserDaoImpl implements UserDao {  
    private EntityManager entityManager;  
  
    public User getUserById( Integer id )  
    {  
        return entityManager.find(User.class, id );  
    }  
    ... ..  
}
```

## DAO Usage in Application Code

### ◆ UserController

```
public class UserController {  
  
    UserDao userDao;  
  
    public String users( ModelMap models )  
    {  
        List<User> users = userDao.getAllUsers();  
        ... ..  
    }  
}
```

## Advantages of DAO

- ◆ Provide a data access API that is
  - Independent of *persistent storage types*, e.g. relational DB, OODB, XML flat files etc.
  - Independent of *persistent storage implementations*, e.g. MySQL, PostgreSQL, Oracle etc.
  - Independent of *data access implementations*, e.g. JDBC, Hibernate, etc.

## Instantiate a UserDao Object in Application Code

1. **UserDaoJpaImpl** userDao =  
    new UserDaoJpaImpl();
2. **UserDao** userDao =  
    new UserDaoJpaImpl();

*Which one is better??*

## Problem Caused by Object Instantiation

- ◆ What if we decide to use JDBC instead of Hibernate/JPA, i.e. replace `UserDaoJpaImpl` with `UserDaoJdbcImpl`
  - The application is not really independent of the data access method
  - Switching to a different `UserDao` implementation affects all the code that uses `UserDao`

## Another Way to Instantiate UserDao

```
UserDao userDao;  
  
...  
  
public void setUserDao( UserDao userDao )  
{  
    this.userDao = userDao;  
}
```

- ◆ No more dependency on a specific implementation of the DAO
- ◆ *But who will call the setter?*

## Inversion of Control (IoC)

- ◆ A framework like Spring is responsible for instantiating the objects and pass them to application code
  - A.K.A. IoC container, bean container
- ◆ Inversion of Control (IoC)
  - The application code is no longer responsible for instantiate an interface with a specific implementation
  - A.K.A. Dependency Injection

## Example: Hello World

- ◆ `Message` is a Java object (or bean) managed by the Spring container
  - Created by the container
  - Property is set by the container

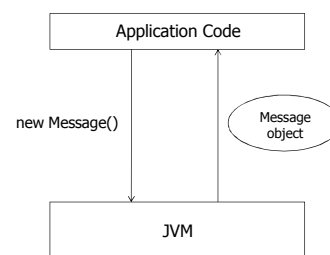
## Bean Configuration File

```
<beans>
  <bean id="msgBean"
        class="cs520.spring.hello.Message">
    <property name="message" value="Hello World!" />
  </bean>
</beans>
```

- ◆ The string "Hello World" is injected to the bean `msgBean`

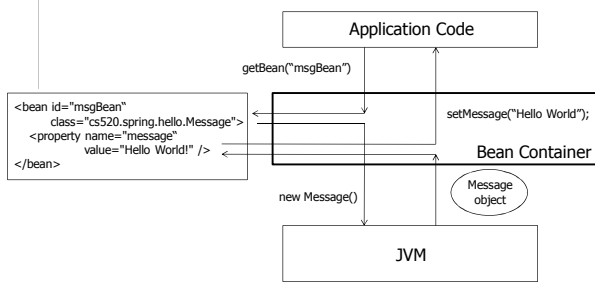
## Understand Bean Container ...

- ◆ Without a bean container



## ... Understand Bean Container

- ◆ With a bean container



## Dependency Injection

- ◆ Objects that can be injected
  - Simple types: strings and numbers
  - Collection types: list, set, and maps
  - Other beans
- ◆ Methods of injection
  - via Setters
  - via Constructors

## Dependency Injection Example

### ◆ DjBean

- Fields of simple types
- Fields of collection types
- Fields of class types

## Quick Summary of Bean Configuration

Bean	<bean>, "id", "class"
Simple type property	<property>, "name", "value"
Class type property	<property>, "name", "ref" (to another <bean>)
Collection type property	<list>/<set>/<map>/<props>, <value>/<ref>/<entry>/<prop>
Constructor arguments	<constructor-arg>, "index", same as other properties

## Some Bean Configuration Examples

```

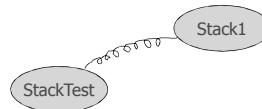
<property name="foo">
  <set>
    <value>bar1</value>
    <ref bean="bar2" />
  </set>
</property>

<property name="foo">
  <map>
    <entry key="key1">
      <value>bar1</value>
    </entry>
    <entry key="key2">
      <ref bean="bar2" />
    </entry>
  </map>
</property>

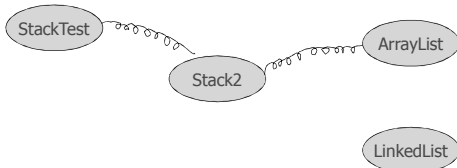
<property name="foo">
  <props>
    <prop key="key1">bar1</prop>
    <prop key="key2">bar2</prop>
  </props>
</property>

```

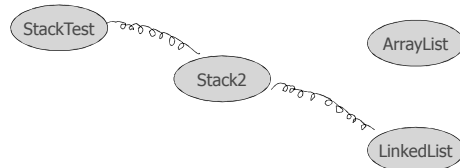
## Wiring – The Stack Example (I)



## Wiring – The Stack Example (II)



## Wiring – The Stack Example (III)



## Annotation-based Configuration

- ◆ Activate annotation processing with `<context:annotation-config />`
- ◆ Automatically scan for Spring bean with `<context:component-scan />`
- ◆ Mark a class to be a Spring bean with `@Component`
- ◆ Enable auto wiring with `@Autowired`

## XML Namespace ...

```
<?xml version="1.0" encoding="UTF-8"?>
<beans xmlns="http://www.springframework.org/schema/beans"
  xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
  xmlns:context="http://www.springframework.org/schema/context"
  xsi:schemaLocation="http://www.springframework.org/schema/beans
    http://www.springframework.org/schema/beans/spring-beans-3.0.xsd
    http://www.springframework.org/schema/context
    http://www.springframework.org/schema/context/spring-context-3.0.xsd">

  <context:annotation-config />

  <context:component-scan base-package="cs520.spring.stack" />

</beans>
```

## ... XML Namespace

```
<?xml version="1.0" encoding="UTF-8"?>
<beans:beans xmlns="http://www.springframework.org/schema/context"
  xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
  xmlns:beans="http://www.springframework.org/schema/beans"
  xsi:schemaLocation="http://www.springframework.org/schema/beans
    http://www.springframework.org/schema/beans/spring-beans-3.0.xsd
    http://www.springframework.org/schema/context
    http://www.springframework.org/schema/context/spring-context-3.0.xsd">

  <annotation-config />

  <component-scan base-package="cs520.spring.stack" />

</beans>
```

## <context:annotation-config />

- ◆ Activate the processing of a number of annotations, e.g.
  - `@Autowired`
  - `@Qualifier`
  - `@Resource`
  - `@PersistenceContext`

## Component Scanning

- ◆ `@Component` for regular bean classes
- ◆ `@Repository` for DAO classes
- ◆ `@Controller` for controller classes
- ◆ `@Service` for service classes

## Auto Wiring

- ◆ Auto wire types
  - `byName`, `byType`, `constructor`, `autodetect`
- ◆ For individual bean
  - `<bean autowire="autowire type"/>`
- ◆ For all beans
  - `<beans default-autowire="autowire type">`

## @Autowired

- ◆ The property does not need a setter
- ◆ Auto wired by type
- ◆ To auto wire by name
  - Use `@Qualifier`
  - Use `@Resource`

## Advantages of IoC

- ◆ Separate application code from service implementation
- ◆ Centralized dependency management with a bean configuration file
- ◆ Singleton objects improve performance
  - *Singleton vs. Prototype*

## Further Readings

- ◆ Spring in Action (3<sup>rd</sup> Ed)
  - Chapter 1-3
- ◆ Spring Framework Reference Documentation  
<http://static.springsource.org/spring/docs/current/spring-framework-reference/html/>
  - Chapter 5 The IoC Container