CS520 Web Programming
Spring – Inversion of Control

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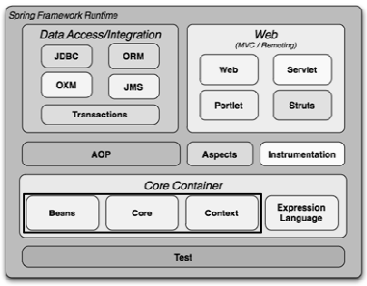
Background

- 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

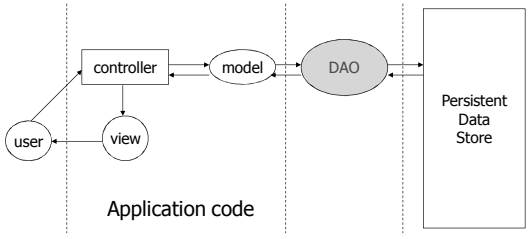


The Need for IoC

- 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 entityManger;

  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

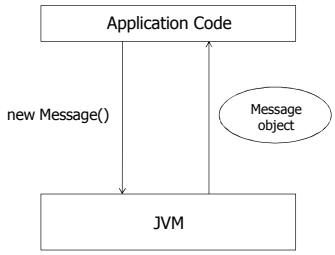
Bean Configuration File

```
<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`

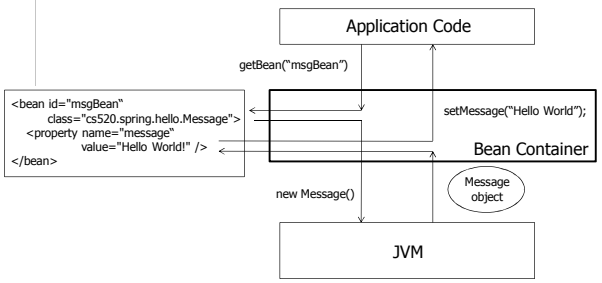
Understand Bean Container …

- 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

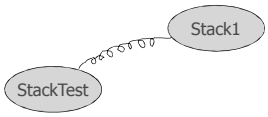
Some Bean Configuration Examples

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

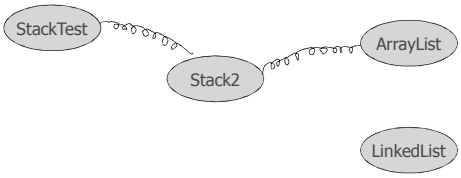
```
<property name="foo">
   <map>
      <entry key="key1">
         <value>bar1</value>
      </entry>
      <entry key="key2">
         <ref bean="bar2" />
      </entry>
   </map>
</property>
```

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

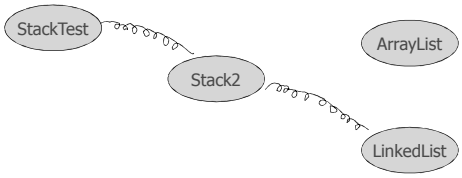
Wiring – The Stack Example (I)



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" />

</bean: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-autowrire="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 (3rd Ed)
  - Chapter 1-3
- Spring Framework Reference Documentation http://static.springsource.org/spring/docs/current/spring-framework-reference/html/
  - Chapter 4 The IoC Container