CS5220 Advanced Topics in Web Programming

Spring – Inversion of Control

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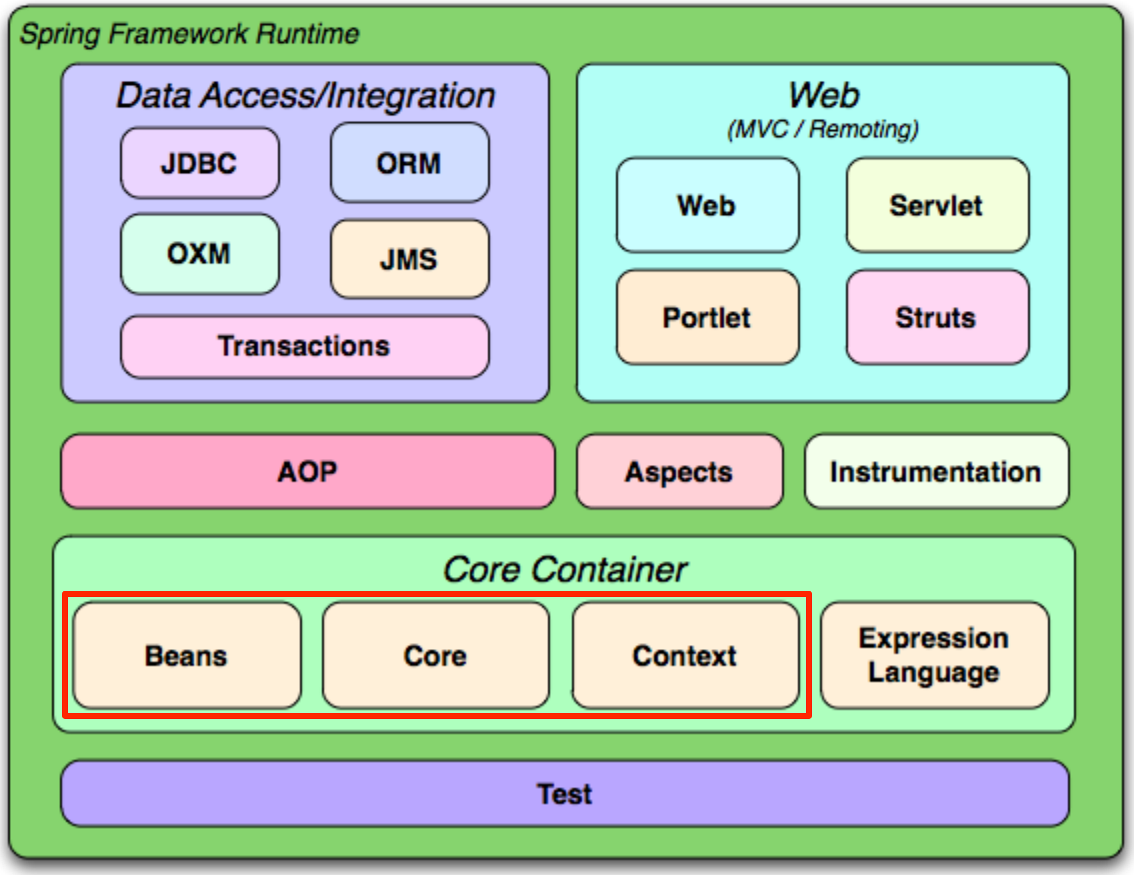
Spring Framework

- The most popular Java web framework (according to hotframeworks.com)
  - Performance, reliability, security, support, …
- Concepts and methodologies that are important not just for web development, but for software development in general

The IoC Container



The Need for IoC

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

Model Class

```
public class User {

    private Integer id;

    private String username, password;

    private boolean enabled;

}
```

DAO Interface

```
public interface UserDao {

    User getUser( Integer id );

    List<User> getUsers();

}
```

DAO Implementation

- Implement `UserDao` using JPA

```
public class UserDaoImpl implements UserDao {

  private EntityManager entityManger;

  public User getUser( Integer id )
  {
    return entityManager.find(User.class, id );
  }
  ... ...
}
```

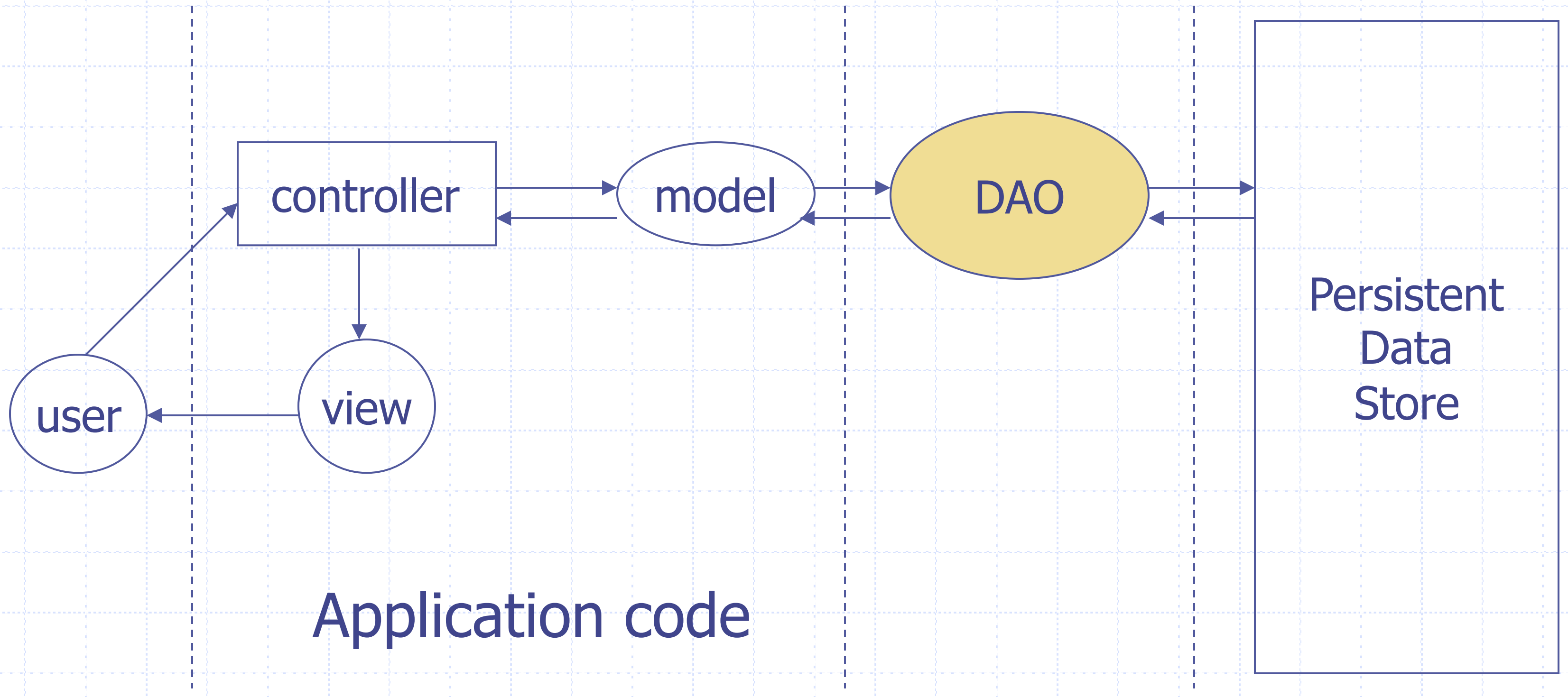
DAO Usage in Application Code

- UserController

```
public class UserController {

    UserDao userDao;

    public String users( ModelMap models )
    {
        List<User> users = userDao.getUsers();
        … …
    }
}
```

Data Access Object (DAO)

- A Java EE design pattern



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 instantiates `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 objects like DAO, i.e. that "control" is taken way from the application code
  - 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

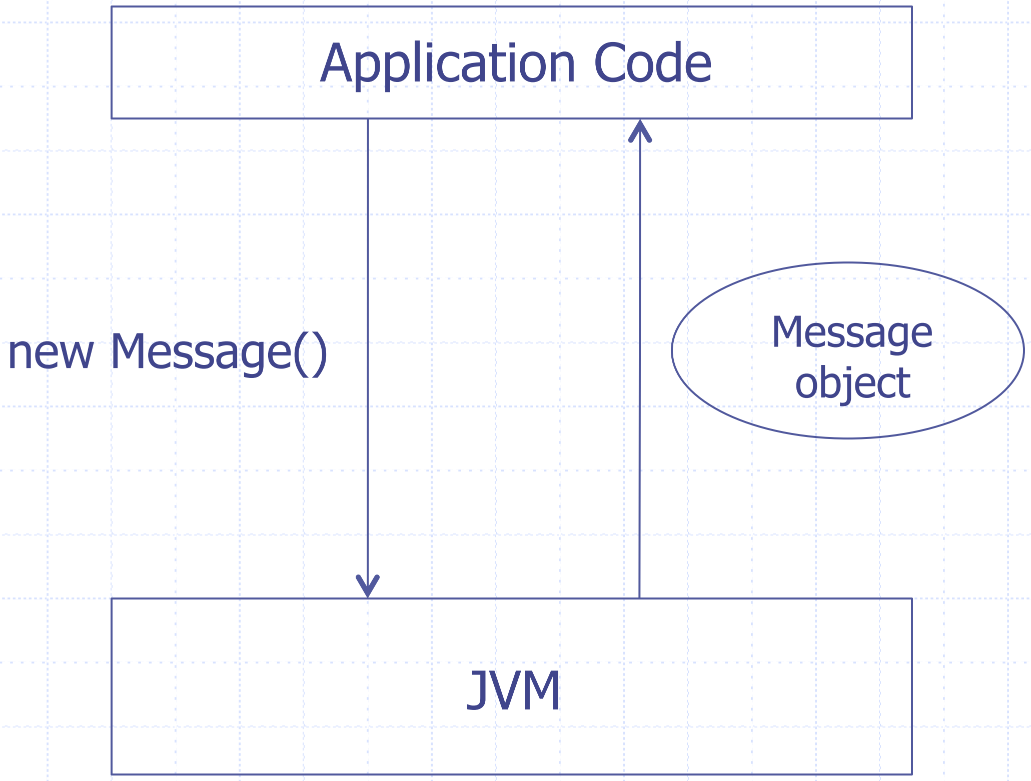
Bean Configuration File

```
<beans>

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

</beans>
```

- The string `“Hello World”` is injected to the bean `msgBean`

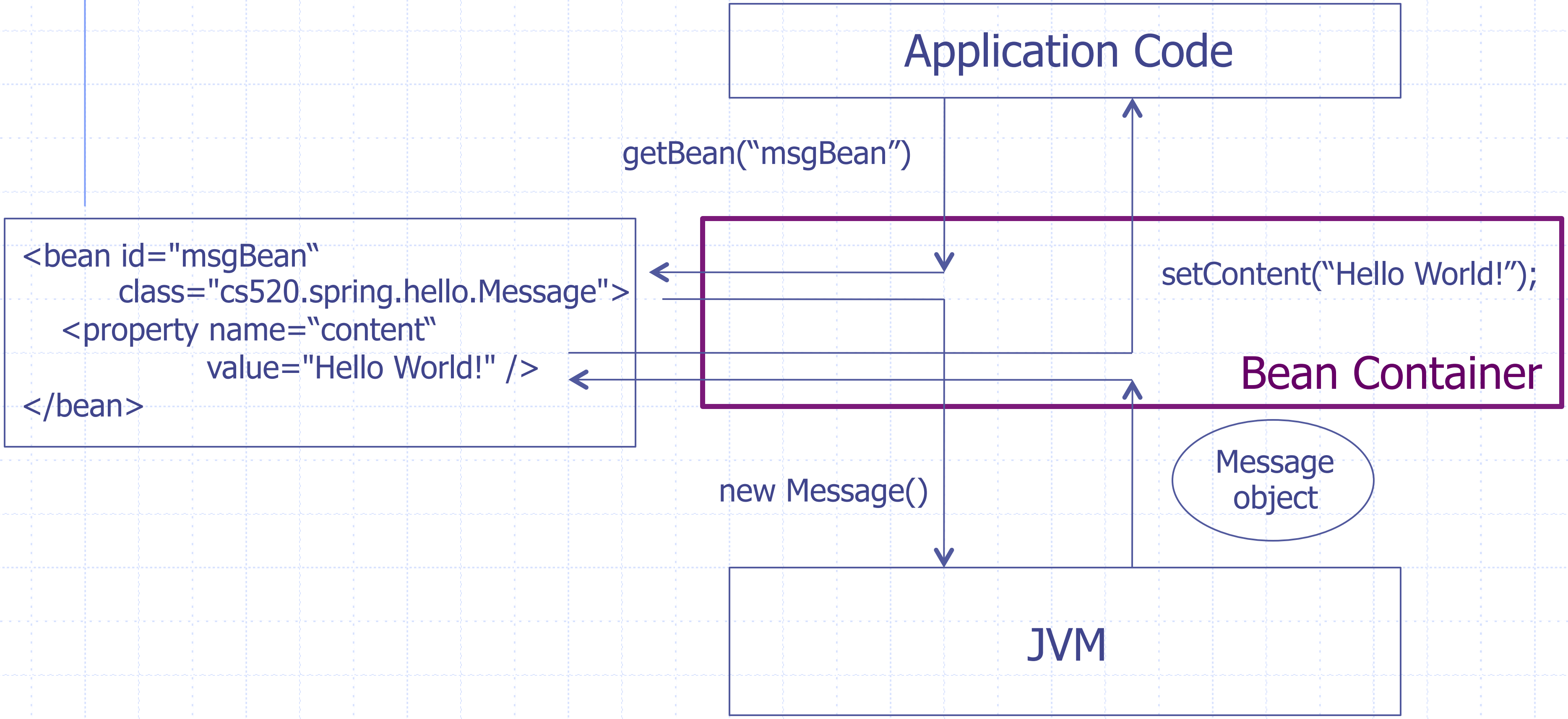
Understand Bean Container …

- Without a bean container



… Understand Bean Container

- With a bean container



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

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

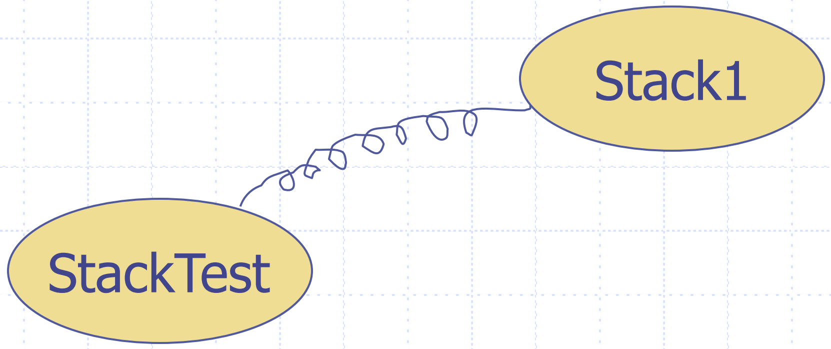
Some Bean Configuration Examples

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

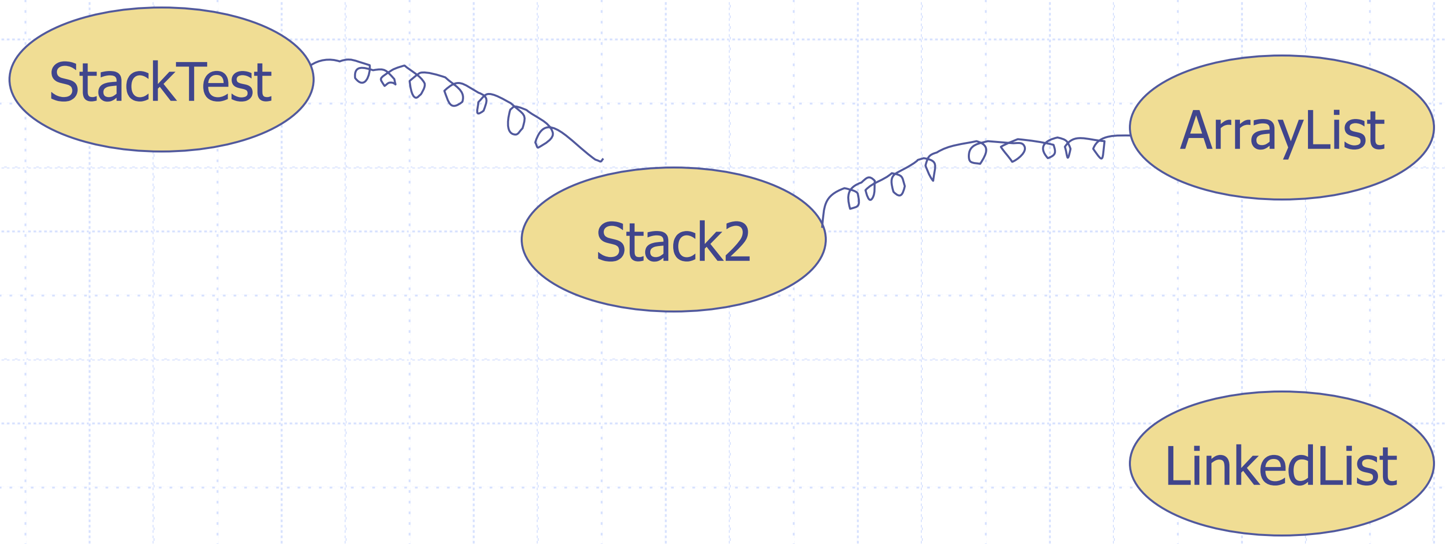
```
<property name="foo">
    <props>
        <prop key="key1">bar1</prop>
        <prop key="key2">bar2</prop>
    </props>
</property>
```

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

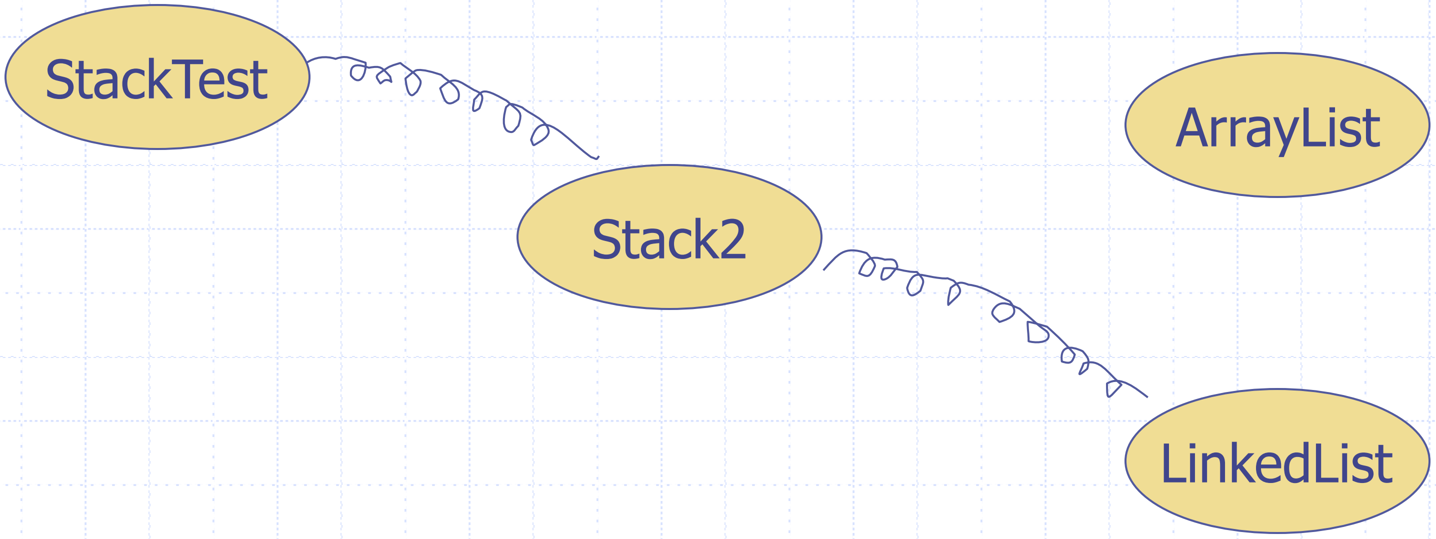
Wiring – The Stack Example (I)



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`

<context:component-scan>

- Scan all the classes under `base-package` and its sub-packages

Annotating Bean Classes

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

Auto Wiring

- Auto wire types
  - `byName, byType, autodetect, constructor`
- 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

- True separation of different components of an application
- Centralized bean dependency management
- Singleton objects improve performance
  - *Singleton vs. Prototype*

Readings

- Spring Framework – Core
  - Chapter 1. The IoC Container