



# spring

## Core Spring

Four Day Workshop

Building Enterprise Applications using Spring

Version 4.3.b

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## Welcome to Core Spring

A 4-day bootcamp that trains you how to use the Spring Framework to create well-designed, testable, business, applications

## Logistics

- Student introductions
- Self introduction
- Course registration (if needed)
- Courseware
- Internet access
- Phones on silent
- Working hours
- Lunch and breaks
- Toilets/Restrooms
- Fire alarms
- Emergency exits
- Any other questions?

**LOGISTICS**

## How You will Benefit

- Learn to use Spring for web and other applications
- Gain hands-on experience
  - Generous mixture of presentation and labs
- Access to experienced, certified instructors



## Covered in this section

- **Agenda**
- Spring and Pivotal



## Course Agenda: Day 1

- Introduction to Spring
- Using Spring to configure an application
- Java-based dependency injection
- Annotation-based dependency injection
- XML-based dependency injection
- Spring FactoryBeans

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## Course Agenda: Day 2

- Understanding the bean life-cycle
- Testing a Spring-based application using multiple profiles
- Adding behavior to an application using aspects
- Introducing data access with Spring
- Simplifying JDBC-based data access

2



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## Course Agenda: Day 3

- Driving database transactions in a Spring environment
- Introducing object-to-relational mapping (ORM)
- Working with JPA in a Spring environment
- Effective web application architecture
- Getting started with Spring MVC

3



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## Course Agenda: Day 4

- Rapidly start new projects with Spring Boot
- Securing web applications with Spring Security
- Implementing REST with Spring MVC
- Microservices and Cloud Native Applications using Spring Cloud

4



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## Covered in this section

- Agenda
- **Spring and Pivotal**



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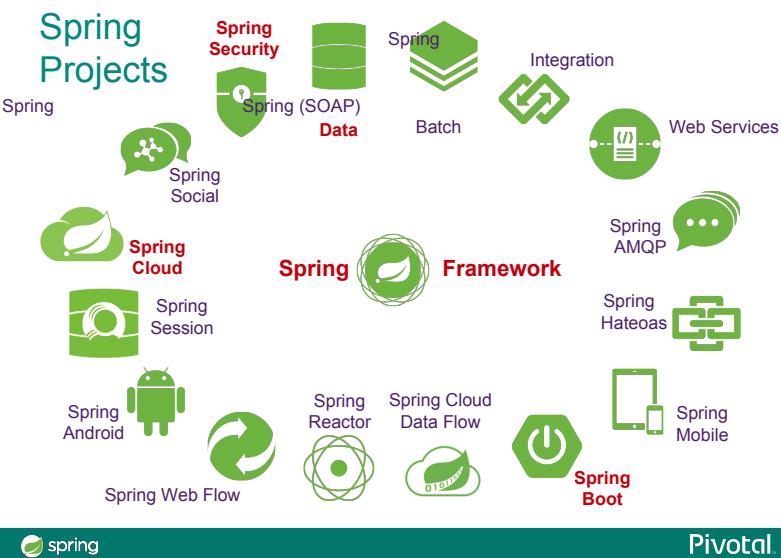
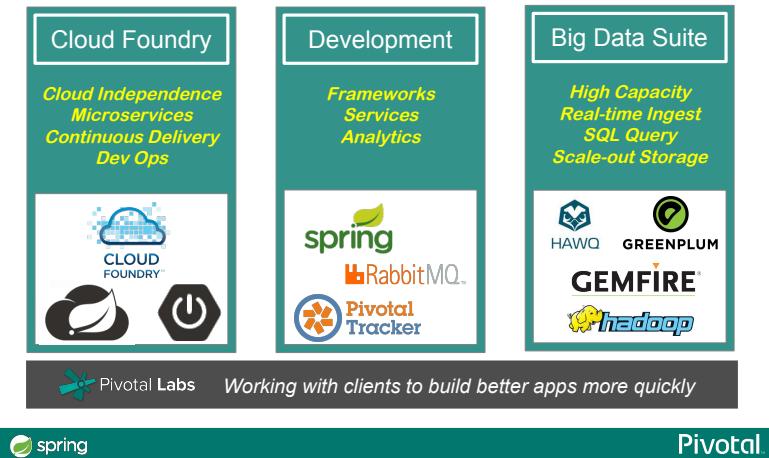
## Spring and Pivotal

- SpringSource, the company behind Spring
  - acquired by VMware in 2009
  - transferred to Pivotal joint venture 2013
- Spring projects key to Pivotal's big-data and cloud strategies
  - Virtualize your Java Apps
    - Save license cost
    - Deploy to private, public, hybrid clouds
  - Real-time analytics
    - Spot trends as they happen
    - Spring Data, Spring Hadoop, Spring XD & Pivotal HD



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# The Pivotal World



## Covered in this section

- Agenda
- Spring and Pivotal

Let's get on with the course..!



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# Overview of the Spring Framework

Introducing Spring in the Context of Enterprise Application Architecture

What is Spring and why would you use it?

## Objectives

- After completing this lesson, you should be able to:
  - Define the Spring Framework
  - Understand what Spring is used for
  - Understand why Spring is successful
  - Explain where it fits in your world



## Topics in this session

- **What is the Spring Framework?**
- Spring is a Container
- Spring Framework history
- What is Spring Used For?



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## What is the Spring Framework?

- Spring is an Open Source, Lightweight, Container and Framework for building Java enterprise applications



- Open Source
- Lightweight
- Container
- Framework



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# What is the Spring Framework?

## Open Source



- Spring binary and source code is freely available
- Apache 2 license
- Code is available at:
  - <https://github.com/spring-projects/spring-framework>
- Binaries available at Maven Central
  - <http://mvnrepository.com/artifact/org.springframework>
- Documentation available at:
  - <http://docs.spring.io/spring/docs/current/spring-framework-reference/htmlsingle>



The use of a transitive dependency management system (Maven, Gradle, Ant/Ivy) is recommended for any Java application



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# What is the Spring Framework?

## Lightweight

- Spring applications do not require a Java EE application server
  - But they can be deployed on one
- Spring is not *invasive*
  - Does not require you to extend framework classes or implement framework interfaces for most usage
  - You write your code as POJOs
- Low overhead
  - Spring jars are relatively small
    - JARs used in this course are < 8 MB



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## What is the Spring Framework? Container

- Spring serves as a container for your application objects.
  - Your objects do not have to worry about finding / connecting to each other.
- Spring instantiates and dependency injects your objects
  - Serves as a lifecycle manager



## What is the Spring Framework? Framework

- Enterprise applications must deal with a wide variety of technologies / resources
  - JDBC, JMS, AMQP, Transactions, ORM / JPA, NoSQL, Security, Web, Tasks, Scheduling, Mail, Files, XML/JSON Marshalling, Remoting, REST services, SOAP services, Mobile, Social, ...
- Spring provides framework classes to simplify working with lower-level technologies



## Topics in this session

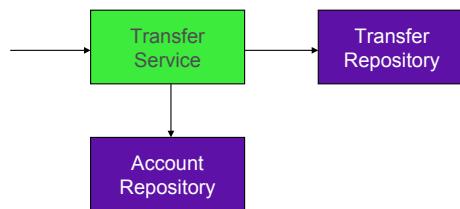
- What is the Spring Framework?
- **Spring is a Container**
- Spring Framework History
- What is Spring Used For?



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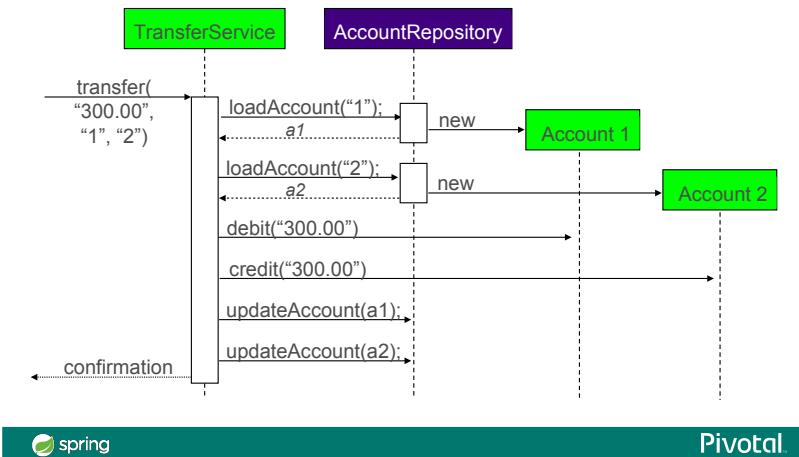
## Application Configuration

- A typical application system consists of several parts working together to carry out a use case



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## Example: Money Transfer System

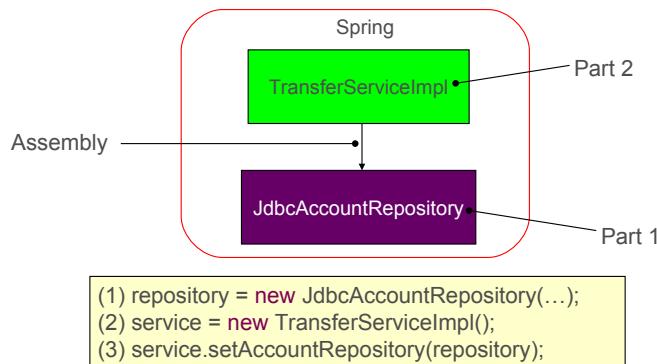


## Spring's Configuration Support

- Spring provides support for assembling such an application system from its parts
  - Parts do not worry about finding each other
  - Any part can easily be swapped out



## Money Transfer System Assembly



spring

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## Parts are Just *Plain Old Java Objects* (POJOs)

```
public class JdbcAccountRepository implements  
    AccountRepository {  
    ...  
}
```

Part 1  
Implements a service (business) interface

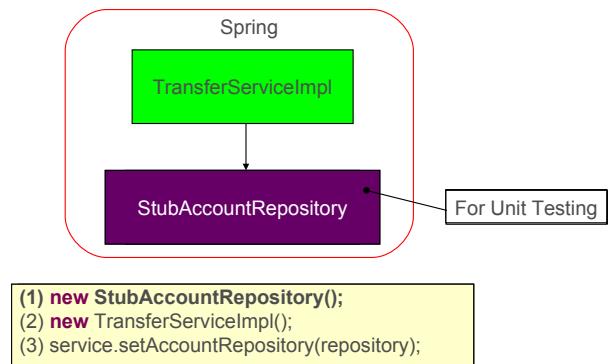
```
public class TransferServiceImpl implements TransferService {  
    private AccountRepository accountRepository;  
  
    public void setAccountRepository(AccountRepository ar) {  
        accountRepository = ar;  
    }  
    ...  
}
```

Part 2  
Depends on an *interface*:  
– conceals complexity of implementation;  
– allows for swapping out implementation

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## Swapping Out Part Implementations



## Topics in this session

- What is the Spring Framework?
- Spring is a Container
- **Spring Framework History**
- What is Spring Used For?



# Why is Spring Successful?

## A brief history of Java

- The early years:
  - 1995 – Java introduced, Applets are popular
  - 1997 – Servlets introduced
    - Efficient, dynamic web pages become possible.
  - 1999 – JSP introduced
    - Efficient, dynamic web pages become easy.
- Questions arise regarding “Enterprise” applications
  - How should a Servlet / JSP application handle:
    - Persistence?
    - Transactions?
    - Security?
    - Business Logic?
    - Messaging?
    - Etc.?



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## Introducing J2EE and EJB

- Java's answer: J2EE
  - 1999 – J2EE introduced
    - Featuring Enterprise Java Beans (EJB)
    - Answers the questions of persistence, transactions, business logic, security, etc
- However EJBs prove to be problematic:
  - Difficult to code.
    - Must extend / implement specific classes /interfaces
    - Complicated programming model required
  - Difficult to unit test
  - Expensive to run
    - Must have application server, resource intensive



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## The Birth of Spring

- Rod Johnson publishes J2EE Development without EJB
- 2004 - Spring Framework 1.0 released
  - Champions dependency injection
  - Encourages POJOs
  - Uses XML files to describe application configuration
  - Becomes popular quickly as an EJB alternative



## Spring Framework History

- Spring 2.0 (2006):
  - XML simplification, async JMS, JPA, AspectJ support
- Spring 2.5 (2007, last release 2.5.6)
  - Requires Java 1.4+ and supports JUnit 4
  - Annotation DI, @MVC controllers, XML namespaces
- Spring 3.x (3.2.17 released July 2016)
  - Environment & Profiles, @Cacheable, @EnableXXX ...
  - Requires Java 1.5+ and JUnit 4.7+
  - REST support, JavaConfig, SpEL, more annotations
- Spring 4.x (released Dec 2013)
  - Support for Java 8, @Conditional, Web-sockets
- Spring 5.x (2017)
  - Reactive programming focus



## Topics in this session

- What is the Spring Framework?
- Spring is a Container
- Spring Framework History
- **What is Spring Used For?**



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## What is Spring Used For?

- Spring provides comprehensive infrastructural support for developing enterprise Java™ applications
  - Spring deals with the plumbing
  - So you can focus on solving the domain problem
- Spring used to build enterprise applications dealing with:



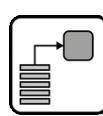
Web Interfaces



Messaging



Persistence



Batch



Integration



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## The Current World

- Spring is not simply an alternative to J2EE / EJB
  - Modern application development challenges are different today than 2000
- Spring continues to innovate
  - **Web:** AJAX, WebSockets, REST, Mobile, Social
  - **Data:** NoSQL, Big Data, Stream processing
  - **Cloud:** Distributed systems, Cloud, Microservices
  - **Productivity:** Spring Boot, Spring Cloud Data Flow
  - and many more



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## More on Spring's Ecosystem



- Visit <http://spring.io/projects>



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# Lab

Developing an Application from Plain  
Java Objects



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# Dependency Injection Using Spring

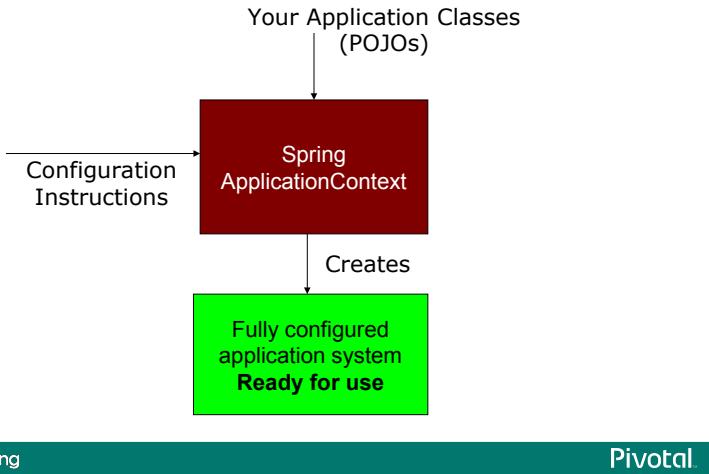
Introducing the Spring Application Context  
and Spring's Java Configuration capability

@Configuration and ApplicationContext

## Topics in this session

- **Spring quick start**
- Creating an application context
- Bean scope
- Lab

## How Spring Works



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## Your Application Classes

```
public class TransferServiceImpl implements TransferService {  
    public TransferServiceImpl(AccountRepository ar) {  
        this.accountRepository = ar;  
    }  
    ...  
}
```

Needed to perform money transfers between accounts

```
public class JdbcAccountRepository implements AccountRepository {  
    public JdbcAccountRepository(DataSource ds) {  
        this.dataSource = ds;  
    }  
    ...  
}
```

Needed to load accounts from the database

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## Configuration Instructions

```
@Configuration  
public class ApplicationConfig {  
    @Bean public TransferService transferService() {  
        return new TransferServiceImpl( accountRepository() );  
    }  
    @Bean public AccountRepository accountRepository() {  
        return new JdbcAccountRepository( dataSource() );  
    }  
    @Bean public DataSource dataSource() {  
        BasicDataSource dataSource = new BasicDataSource();  
        dataSource.setDriverClassName("org.postgresql.Driver");  
        dataSource.setUrl("jdbc:postgresql://localhost/transfer");  
        dataSource.setUsername("transfer-app");  
        dataSource.setPassword("secret45");  
        return dataSource;  
    }  
}
```



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## Creating and Using the Application

```
// Create the application from the configuration  
ApplicationContext context =  
    SpringApplication.run( ApplicationConfig.class );  
  
// Look up the application service interface  
TransferService service =  
    (TransferService) context.getBean("transferService");  
  
// Use the application  
service.transfer(new MonetaryAmount("300.00"), "1", "2");
```

**Bean ID**  
Based on method name



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## Accessing a Bean

- Multiple ways

```
ApplicationContext context = SpringApplication.run(...);

// Classic way: cast is needed
TransferService ts1 = (TransferService) context.getBean("transferService");

// Use typed method to avoid cast
TransferService ts2 = context.getBean("transferService", TransferService.class);

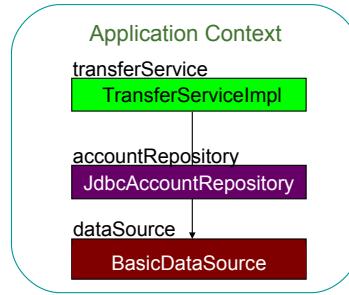
// No need for bean id if type is unique
TransferService ts3 = context.getBean(TransferService.class);
```



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## Inside the Spring Application Context

```
// Create the application from the configuration
ApplicationContext context =
    SpringApplication.run(ApplicationConfig.class);
```



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## Bean Descriptions

- Allows you to provide helpful information about any bean

```
@Bean  
{@Description("Handles all transfer related use-cases")  
public TransferService transferService() { ... }  
  
@Bean  
{@Description("Provides access to data from the Accounts table")  
public AccountRepository accountRepository() { ... }  
  
@Bean  
{@Description("Data-source for the underlying RDB we are using")  
public DataSource dataSource() { ... }}
```



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## Quick Start Summary

- Spring separates application configuration from application objects
- Spring manages your application objects
  - Creating them in the correct order
  - Ensuring they are fully initialized before use
- Each bean is given a unique id / name
  - Should reflect service or role the bean provides to clients
  - Bean ids should not contain implementation details



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## Topics in this session

- Spring quick start
- **Creating an application context**
- Multiple Configuration Files
- Bean scope
- Lab



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## Creating a Spring Application Context

- Spring application contexts can be bootstrapped in any environment, including
  - JUnit system test
  - Web application
  - Standalone application



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## ApplicationContext Example

### Instantiating Within a System (Integration) Test

```
public class TransferServiceTests {  
    private TransferService service;  
  
    @Before public void setUp() {  
        // Create the application from the configuration  
        ApplicationContext context =  
            SpringApplication.run( ApplicationConfig.class )  
        // Look up the application service interface  
        service = context.getBean(TransferService.class);  
    }  
  
    @Test public void moneyTransfer() {  
        Confirmation receipt =  
            service.transfer(new MonetaryAmount("300.00"), "1", "2");  
        Assert.assertEquals("500.00", receipt.getNewBalance());  
    }  
}
```

Bootstraps the system to test

Tests the system



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## Topics in this session

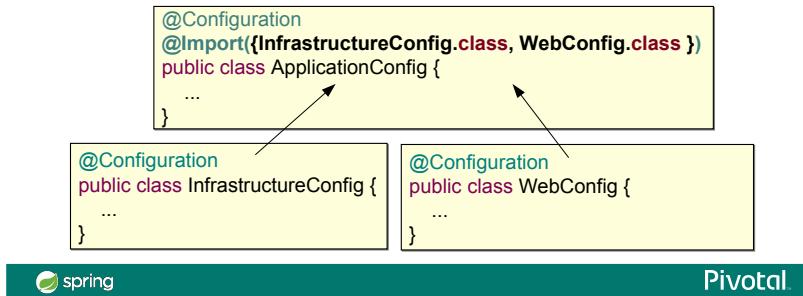
- Spring quick start
- Creating an application context
- **Multiple Configuration Files**
- Bean scope
- Lab



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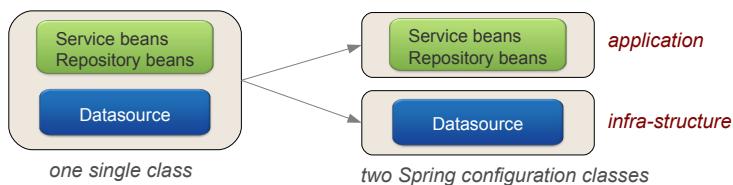
## Creating an Application Context from Multiple Files

- Your `@Configuration` class can get very long
  - Instead use *multiple* files combined with `@Import`
  - Defines a single Application Context
    - With beans sourced from multiple files



## Creating an Application Context from Multiple Files

- Organize your `@Configuration` classes however you like
- Best practice: separate out “application” beans from “infrastructure” beans
  - Infrastructure often changes between environments



## Mixed Configuration

```
@Configuration  
public class ApplicationConfig {  
  
    @Bean public TransferService transferService()  
    { return new TransferServiceImpl( accountRepository() ); }  
  
    @Bean public AccountRepository accountRepository()  
    { return new JdbcAccountRepository( dataSource() ); }  
  
    @Bean public DataSource dataSource()  
    {  
        BasicDataSource dataSource = new BasicDataSource();  
        dataSource.setDriverClassName("org.postgresql.Driver");  
        dataSource.setUrl("jdbc:postgresql://localhost/transfer");  
        dataSource.setUsername("transfer-app");  
        dataSource.setPassword("secret45");  
        return dataSource;  
    }  
}
```

application beans

Coupled to a local Postgres environment

infrastructure bean



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## Partitioning Configuration

```
@Configuration  
public class ApplicationConfig {  
    @Autowired DataSource dataSource;  
  
    @Bean public TransferService transferService()  
    { return new TransferServiceImpl( accountRepository() ); }  
  
    @Bean public AccountRepository accountRepository()  
    { return new JdbcAccountRepository( dataSource ); }  
}  
  
{@Configuration  
public class TestInfrastructureConfig {  
    @Bean public DataSource dataSource() {  
        ...  
    }  
}
```

application beans

infrastructure bean



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## Referencing Beans Defined in Another File

- Use `@Autowired` to reference a bean defined elsewhere

```
@Configuration  
@Import( InfrastructureConfig.class )  
public class AppConfig {  
    private final DataSource dataSource;  
  
    @Autowired  
    public AppConfig(DataSource ds) {  
        this.dataSource = ds;  
    }  
  
    @Bean  
    public AccountRepository accountRepository() {  
        return new JdbcAccountRepository( dataSource );  
    }  
}
```

Pre Spring 4.3: Auto-wire a property setter, can't use a constructor



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## Referencing Dependencies Via Arguments

- *Alternative:* Define `@Bean` method arguments
  - Spring finds bean that matches type & populates the argument

```
@Configuration  
@Import( InfrastructureConfig.class )  
public class ApplicationConfig {  
    @Bean  
    public AccountRepository accountRepository( DataSource dataSource ) {  
        return new JdbcAccountRepository( dataSource );  
    }  
}
```

```
@Configuration  
public class InfrastructureConfig {  
    @Bean public DataSource dataSource() {  
        DataSource ds = new BasicDataSource();  
        ...  
        return ds;  
    }  
}
```



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## ... But Avoid “Tramp Data”

```
@Configuration  
@Import( InfrastructureConfig.class )  
public class ApplicationConfig {  
    @Bean public AccountService accountService( DataSource dataSource ){  
        return new accountService( accountRepository(dataSource) );  
    }  
  
    @Bean public AccountService accountRepository( DataSource dataSource ) {  
        return new accountRepository( dataSource );  
    }  
}  
  
@Configuration  
@Import( InfrastructureConfig.class )  
public class ApplicationConfig {  
    @Bean public AccountService accountService( AccountRepository repo ) {  
        return new accountService( repo );  
    }  
    @Bean public AccountService accountRepository( DataSource ds ) {  
        return new accountRepository( ds );  
    }  
}
```

**Bad: dataSource is a “tramp”!**

**tramp**

**Better: Pass *actual* dependency**



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## Beware Duplicate Beans

Use `@Order` annotation  
to control which order  
`@Bean` methods run  
(since Spring 4.2)

- It is *not* illegal to define the same bean more than once
  - You get the last bean Spring sees defined

```
@Configuration  
public class Config1 {  
    @Bean  
    public String example() {  
        return new String("example1");  
    }  
}  
  
@Configuration  
public class Config2 {  
    @Bean  
    public String example() {  
        return new String("example2");  
    }  
}  
  
@Import({ Config1.class, Config2.class })  
public class TestApp {  
    public static void main(String[] args) {  
        ApplicationContext context = SpringApplication.run(TestApp.class);  
        System.out.println("Id=" + context.getBean("example"));  
    }  
}
```

Console output is `Id=example2`



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## Topics in this session

- Spring quick start
- Creating an application context
- Multiple Configuration Files
- **Bean scope**
- Lab

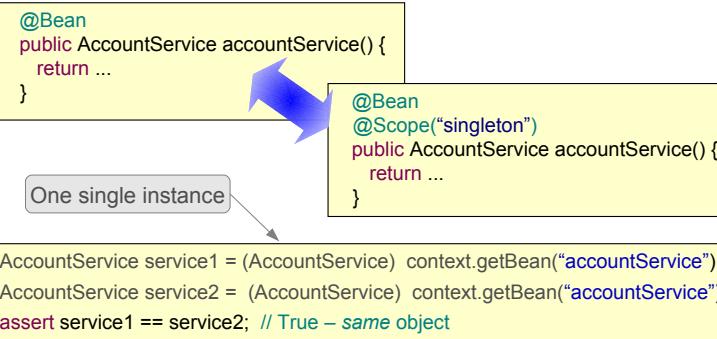


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### Bean Scope: default

service1 == service2

- Default scope is *singleton*



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## Bean Scope: prototype

service1 != service2

- Scope "prototype"
  - New instance created every time bean is referenced

```
@Bean  
@Scope("prototype")  
public AccountService accountService() {  
    return ...  
}
```

```
@Scope(scopeName="prototype")
```

```
AccountService service1 = (AccountService) context.getBean("accountService");  
AccountService service2 = (AccountService) context.getBean("accountService");  
assert service1 != service2; // True – different objects
```

TWO instances



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## Common Spring Scopes

- The most commonly used scopes are:

**singleton** A single instance is used

**prototype** A new instance is created each time the bean is referenced

**session** A new instance is created once per user session - web environment only

**request** A new instance is created once per request – web environment only



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## Other Scopes

- Spring has other more specialized scopes
  - Web Socket scope
  - Refresh Scope
  - Thread Scope (defined but not registered by default)
- Custom scopes (rarely)
  - You define a factory for creating bean instances
  - Register to define a custom scope name
- All are outside the scope of this course



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## Dependency Injection Summary

- Your object is handed what it needs to work
  - Frees it from the burden of resolving its dependencies
  - Simplifies your code, improves code reusability
- Promotes programming to interfaces
  - Conceals implementation details of dependencies
- Improves testability
  - Dependencies easily stubbed out for unit testing
- Allows for centralized control over object lifecycle
  - Opens the door for new possibilities



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# Lab

Using Spring to Configure an Application



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# Dependency Injection Using Spring 2

Deeper Look into Spring's Java  
Configuration Capability

External Properties, Profiles and Proxies

## Topics in this session

- **External Properties**
- Profiles
- Spring Expression Language
- Proxying

## Setting property values

- Consider this bean definition from the last chapter:

```
@Bean  
public DataSource dataSource() {  
    DataSource ds = new BasicDataSource();  
    ds.setDriverClassName("org.postgresql.Driver");  
    ds.setUrl("jdbc:postgresql://localhost/transfer");  
    ds.setUser("transfer-app");  
    ds.setPassword("secret45");  
    return ds;  
}
```

- Unwise to hard-code DB connection parameters
  - “Externalize” these to a properties file



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## Spring's Environment Abstraction – 1

- Environment** object used to obtain properties from runtime environment
- Properties from many sources:
  - JVM System Properties
  - Java Properties Files
  - Servlet Context Parameters
  - System Environment Variables
  - JNDI



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## Spring's Environment Abstraction – 2

```
@Configuration  
public class DbConfig {  
    private static final String DB_DRIVER = "db.driver";  
    private static final String DB_URL = "db.url";  
    private static final String DB_USER = "db.user";  
    private static final String DB_PWD = "db.password";  
  
    @Autowired public Environment env;  
  
    @Bean public DataSource dataSource() {  
        DataSource ds = new BasicDataSource();  
        ds.setDriverClassName( env.getProperty( DB_DRIVER ) );  
        ds.setUrl( env.getProperty( DB_URL ) );  
        ds.setUser( env.getProperty( DB_USER ) );  
        ds.setPassword( env.getProperty( DB_PWD ) );  
        return ds;  
    }  
}
```

Property names

Fetch property values from environment



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## Property Sources

- Environment obtains values from “property sources”
  - *Environment Variables* and *Java System Properties* always populated automatically
  - **@PropertySource** contributes *additional* properties
  - Available resource prefixes: classpath: file: http:

```
@Configuration  
@PropertySource ( "classpath:/com/organization/config/app.properties" )  
@PropertySource ( "file:config/local.properties" )  
public class ApplicationConfig {  
    ...  
}
```

Adds properties from these files *in addition to* environment variables and system properties



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## Accessing Properties using @Value

```
@Configuration  
public class DbConfig {  
  
    @Bean  
    public DataSource dataSource(  
        @Value("${db.driver}") String driver,  
        @Value("${db.url}") String url,  
        @Value("${db.user}") String user,  
        @Value("${db.password}") String pwd) {  
        DataSource ds = new BasicDataSource();  
        ds.setDriverClassName( driver);  
        ds.setUrl( url);  
        ds.setUser( user);  
        ds.setPassword( pwd));  
        return ds;  
    }  
}
```

Convenient alternative to explicitly using Environment

BUT: How are these \${...} variables resolved? Next slide ...



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## Evaluating \${...} Variables

- \${...} variables are evaluated by a dedicated Spring bean
  - The `PropertySourcesPlaceholderConfigurer`
  - **Note:** make this a `static` bean
    - Ensures \${..} placeholder expressions are evaluated *before* any beans are created that might use them

```
@Bean  
public static PropertySourcesPlaceholderConfigurer pspc() {  
    return new PropertySourcesPlaceholderConfigurer();  
}
```

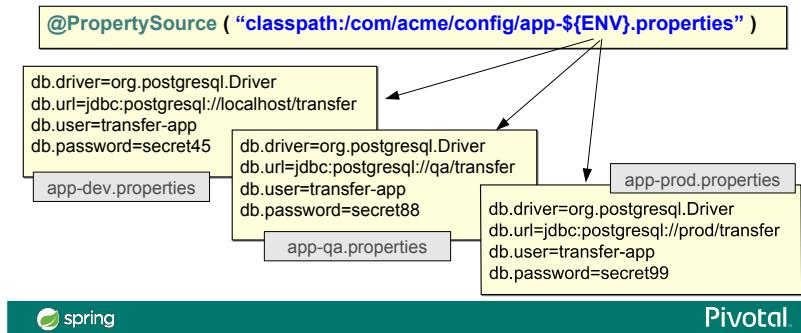
• \${..} placeholders are *not resolved unless this bean declared*



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## `${...}` Placeholders

- `${...}`  placeholders in a `@PropertySource` are resolved against existing properties
  - Such as System properties & Environment variables

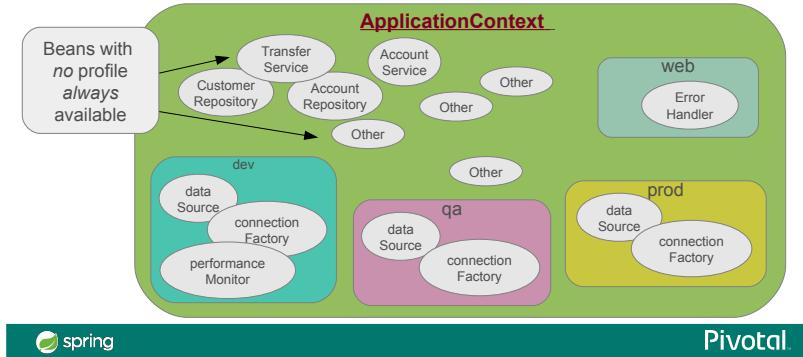


## Topics in this session

- External Properties
- **Profiles**
- Spring Expression Language
- Proxying

## Profiles

- Beans can be grouped into Profiles
  - Profiles can represent purpose: "web", "offline"
  - Or environment: "dev", "qa", "uat", "prod"
  - Beans included / excluded based on profile membership



## Defining Profiles – 1

- Using **@Profile** annotation on configuration class
  - All beans in Configuration belong to the profile

```
@Configuration  
{@Profile("dev")}  
public class DevConfig {  
  
    @Bean  
    public DataSource dataSource() {  
        EmbeddedDatabaseBuilder builder = new EmbeddedDatabaseBuilder();  
        return builder.setName("testdb")  
            .setType(EmbeddedDatabaseType.HSQL)  
            .addScript("classpath:/testdb/schema.db")  
            .addScript("classpath:/testdb/test-data.db").build();  
    }  
    ...  
}
```



## Defining Profiles - 2

- Using **@Profile** annotation on **@Bean** methods

```
@Configuration  
public class DataSourceConfig {  
    @Bean(name="dataSource")  
    @Profile("dev")  
    public DataSource dataSourceForDev() {  
        EmbeddedDatabaseBuilder builder = new EmbeddedDatabaseBuilder();  
        return builder.setName("testdb") ...  
    }  
  
    @Bean(name="dataSource")  
    @Profile("prod")  
    public DataSource dataSourceForProd() {  
        DataSource dataSource = new BasicDataSource();  
        ...  
        return dataSource;  
    }  
}
```

Explicit bean-name overrides method name

Both profiles define same bean id, so only one profile should be activated at a time.



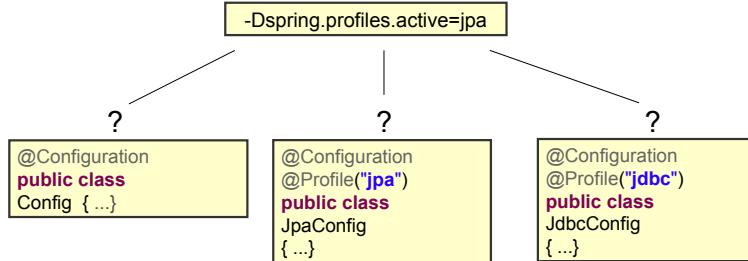
## Ways to Activate Profiles

- Profiles must be activated at run-time
    - System property via command-line
    - System property programmatically
    - Integration Test: Use **@ActiveProfiles** (later section)
      - Note: **@ActiveProfiles** only works in a Spring-driven test
- ```
-Dspring.profiles.active=dev,jpa
```
- ```
System.setProperty("spring.profiles.active", "dev,jpa");  
SpringApplication.run(AppConfig.class);
```



## Quiz:

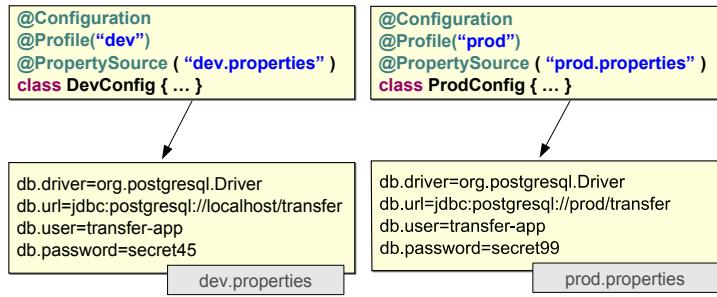
### Which of the Following is/are Selected?



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## Property Source selection

- @Profile can control which @PropertySources are included in the Environment



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## Topics in this session

- External Properties
- Profiles
- **Spring Expression Language**
- Proxying



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## Spring Expression Language

- SpEL for short
  - Inspired by the Expression Language used in Spring WebFlow
  - Based on Unified Expression Language used by JSP and JSF
- Pluggable/extendable by other Spring-based frameworks



This is just a brief introduction, for full details see  
<http://docs.spring.io/spring/docs/current/spring-framework-reference/html/expressions.html>



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## SpEL examples – Using @Value

```
@Configuration  
class TaxConfig  
{  
    @Value("#{ systemProperties['user.region'] }") String region;  
  
    @Bean public TaxCalculator taxCalculator1() {  
        return new TaxCalculator( region );  
    }  
  
    @Bean public TaxCalculator taxCalculator2  
        (@Value("#{ systemProperties['user.region'] }") String region, ...) {  
        return new TaxCalculator( region );  
    }  
    ...  
}
```

**Option 1:** Set an attribute then use it

**Option 2:** Pass as a bean method argument



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## SpEL – Accessing Spring Beans

```
class StrategyBean {  
    private KeyGenerator gen = new KeyGenerator.getInstance("Blowfish");  
    public KeyGenerator getKeyGenerator() { return gen; }  
}  
  
@Configuration  
class StrategyConfig  
{  
    @Bean public StrategyBean strategyBean() {  
        return new StrategyBean();  
    }  
}  
  
@Configuration  
class AnotherConfig  
{  
    @Value("#{strategyBean.keyGenerator}") KeyGenerator kgen;  
    ...  
}
```



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## Accessing Properties

- Can access properties via the *environment*
  - These are equivalent

```
@Value("${daily.limit}")
int maxTransfersPerDay;
```

```
@Value("#{environment['daily.limit']}")
int maxTransfersPerDay;
```

- Properties are Strings
  - May need to cast in expressions

```
@Value("#{new Integer(environment['daily.limit']) * 2}")
@Value("#{new java.net.URL(environment['home.page']).host}")
```



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## SpEL

- EL Attributes can be:
  - Spring beans (like *strategyBean*)
  - Implicit references
    - Spring's *environment*, *systemProperties*, *systemEnvironment* available by default
    - Others depending on context
- SpEL allows to create custom functions and references
  - Widely used in Spring projects
    - Spring Security, Spring WebFlow
    - Spring Batch, Spring Integration
  - Each may add *their own* implicit references



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## Topics in this session

- External Properties
- Profiles
- Spring Expression Language
- **Proxying**



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## Quiz

```
@Bean implementation?  
public AccountRepository accountRepository() {  
    return new JdbcAccountRepository();  
}
```

```
@Bean  
public TransferService transferService1() {  
    TransferServiceImpl service = new TransferServiceImpl();  
    service.setAccountRepository(accountRepository());  
    return service;  
}
```

```
@Bean  
public TransferService transferService2() {  
    return new TransferServiceImpl( new JdbcAccountRepository() );  
}
```

1. Method call?

2. New instance?

**Prefer call to dedicated method. Let's discuss why ...**



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## Working with Singletons

```
@Bean  
public AccountRepository accountRepository() {  
    return new JdbcAccountRepository();  
}  
  
@Bean  
public TransferService transferService() {  
    TransferServiceImpl service = new TransferServiceImpl();  
    service.setAccountRepository(accountRepository());  
    return service;  
}  
  
@Bean  
public AccountService accountService() {  
    return new AccountServiceImpl( accountRepository() );  
}
```

Singleton??

Method called twice more

HOW IS IT POSSIBLE?



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## Singletons Require Proxies

- At startup time, a proxy subclass is created
  - Subclass performs *scope-control*
    - Only calls *super* on *first* invocation of singleton bean method
    - Singleton instance is cached by the *ApplicationContext*

```
@Configuration  
public class AppConfig {  
    @Bean public AccountRepository accountRepository() { ... }  
    @Bean public TransferService transferService() { ... }  
}
```

↑ *inherits from*

```
public class AppConfig$$EnhancerByCGLIB$$ extends AppConfig {  
    public AccountRepository accountRepository() { // ... }  
    public TransferService transferService() { // ... }  
}
```



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## Inheritance-based Proxies

- Child class is the entry point

```
public class AppConfig$$EnhancerByCGLIB$ extends AppConfig {  
  
    public AccountRepository accountRepository() {  
        // if bean is in the applicationContext, then return bean  
        // else call super.accountRepository(), store bean in context, return bean  
    }  
  
    public TransferService transferService() {  
        // if bean is in the applicationContext, then return bean  
        // else call super.transferService(), store bean in context, return bean  
    }  
}
```



Java Configuration uses *cglib* for inheritance-based proxies



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## Summary

- Property values are easily externalized using Spring's Environment abstraction
- Profiles are used to group sets of beans
- Spring Expression Language
- Spring proxies your @Configuration classes to allow for scope control.



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# Annotations in Spring

Annotations for Dependency Injection and Interception

Component scanning and auto-injection

## Topics in this Session

- Fundamentals
  - Annotation-based Configuration
  - Best practices: when to use what?
  - @PostConstruct and @PreDestroy
  - Stereotypes and meta annotations
- Lab
- Advanced features
  - @Resource
  - Standard annotations (JSR 330)

## Before – Explicit Bean Definition

- Configuration is external to bean-class
  - Separation of concerns
  - Java-based dependency injection

```
@Configuration  
public class TransferModuleConfig {  
  
    @Bean public TransferService transferService() {  
        return new TransferServiceImpl( accountRepository() );  
    }  
  
    @Bean public AccountRepository accountRepository() {  
        ...  
    }  
}
```

Dependency  
Injection



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## After - Implicit Configuration

- Annotation-based configuration *within* bean-class

```
@Component  
public class TransferServiceImpl implements TransferService {  
    @Autowired  
    public TransferServiceImpl(AccountRepository repo) {  
        this.accountRepository = repo;  
    }  
}
```

Bean id derived from classname: *transferServiceImpl*

Annotations embedded  
with POJOs

```
@Configuration  
@ComponentScan ( "com.bank" )  
public class AnnotationConfig {  
    // No bean definition needed any more  
}
```

Find @Component classes  
within designated (sub)packages



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## Usage of @Autowired

Unique dependency of  
correct **type** must exist

- Constructor-injection

```
@Autowired  
public TransferServiceImpl(AccountRepository a) {  
    this.accountRepository = a;  
}
```

- Method-injection

```
@Autowired  
public void setAccountRepository(AccountRepository a) {  
    this.accountRepository = a;  
}
```

- Field-injection

```
@Autowired  
private AccountRepository accountRepository;
```

Even when field is private!!  
– but hard to unit test, see URL



<http://olivergierke.de/2013/11/why-field-injection-is-evil/>

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## @Autowired dependencies: required or not?

- Default behavior: required

```
@Autowired  
public void setAccountRepository(AccountRepository a) {  
    this.accountRepository = a;  
}
```

Exception if no  
dependency found

- Use required attribute to override default behavior

```
@Autowired(required=false)  
public void setAccountRepository(AccountRepository a) {  
    this.accountRepository = a;  
}
```

Only inject if  
dependency exists



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## Java 8 Optional<T>

- Another way to inject optional dependencies
  - `Optional<T>` introduced to reduce null pointer errors

```
@Autowired(required=false)
AccountService accountService;

public void doSomething() {
    if (accountService != null) {
        // do something
    }
}
```

```
@Autowired
Optional<AccountService> accountService;

public void doSomething() {
    accountService.ifPresent( s -> {
        // s is the AccountService instance,
        // use s to do something
    });
}
```

Note the use of the lambda



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## Constructor vs Setter Dependency Injection

- Spring doesn't care – can use either
  - But which is best?

Constructors	Setters
Mandatory dependencies	Optional / changeable dependencies
Immutable dependencies	Circular dependencies
Concise (pass several params at once)	Inherited automatically If constructor needs too many params

- Follow the same rules as standard Java
  - Be consistent across your project team
  - Many classes use both



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## Autowiring and Disambiguation – 1

- What happens here?

```
@Component  
public class TransferServiceImpl implements TransferService {  
    @Autowired  
    public TransferServiceImpl(AccountRepository accountRepository) { ... }  
}
```

```
@Component  
public class JpaAccountRepository implements AccountRepository {..}  
  
@Component  
public class JdbcAccountRepository implements AccountRepository {..}
```

Which one should get injected?

At startup: *NoSuchBeanDefinitionException*, no unique bean of type [AccountRepository] is defined: expected single bean but found 2...



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## Autowiring and Disambiguation – 2

- Use of the @Qualifier annotation

```
@Component("transferService")  
public class TransferServiceImpl implements TransferService {  
    @Autowired  
    public TransferServiceImpl( @Qualifier("jdbcAccountRepository")  
        AccountRepository accountRepository) { ... }  
  
    @Component("jdbcAccountRepository")  
    public class JdbcAccountRepository implements AccountRepository {..}  
  
    @Component("jpaAccountRepository")  
    public class JpaAccountRepository implements AccountRepository {..}
```

qualifier

bean ID



@Qualifier also available with method injection and field injection  
Component names should *not* show implementation details *unless*  
there are 2 implementations of the *same* interface (as here)



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## Autowiring and Disambiguation – 3

- Autowired resolution rules
  - Look for unique bean of required *type*
  - Use `@Qualifier` if supplied
  - Try to find a matching bean by *name*
- Example
  - We have multiple *Queue* beans
  - Spring finds bean with id matching what is being set: “`ack`”

```
@Autowired  
public myBean(Queue ack) {  
    ...  
}
```

```
@Autowired  
public void setQueue(Queue ack) {  
    ...  
}
```

```
@Autowired  
private Queue ack;
```

Looks for Queue bean with id = “`ack`”



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## Using `@Value` to set Attributes

- Constructor-injection

Can use \$ variables or  
SpEL

```
@Autowired  
public TransferServiceImpl(@Value("${daily.limit}") int max) {  
    this.maxTransfersPerDay = max;  
}
```

- Method-injection

```
@Autowired  
public void setDailyLimit(@Value("${daily.limit}") int max) {  
    this.maxTransfersPerDay = max;  
}
```

- Field-injection

```
@Value("#${environment['daily.limit']}")  
int maxTransfersPerDay;
```

Not private so we can  
initialize in a unit-test



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## More on @Value

- Providing a fall-back value
  - If `daily.limit` undefined, use colon :

```
@Autowired  
public TransferServiceImpl(@Value("${daily.limit : 100000}") int max) {  
    this.maxTransfersPerDay = max;  
}
```

– For SpEL, use the “Elvis” operator `?:`

```
@Autowired  
public setLimit(@Value("#{environment[daily.limit] ?: 100000}") int max) {  
    this.maxTransfersPerDay = max;  
}
```

`x ?: y` is short for `x != null ? x : y`

Equivalent operators



Elvis lives!



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## Component Names

- When not specified
  - Names are auto-generated
    - De-capitalized non-qualified classname by default
    - But will pick up implementation details from classname
  - *Recommendation:* never rely on generated names!
- When specified
  - Allow disambiguation when 2 bean classes implement the same interface



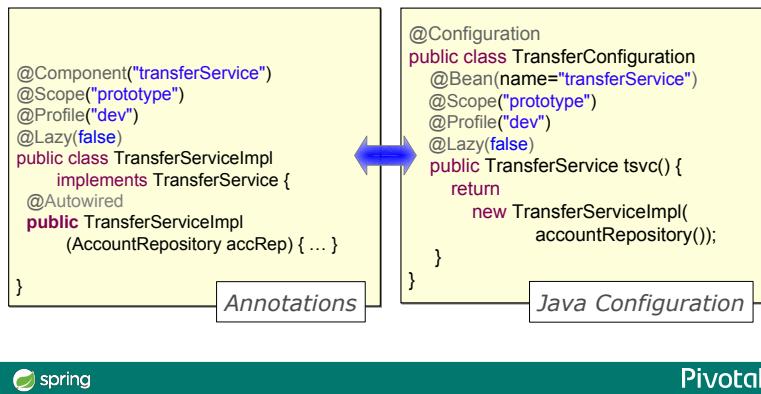
Common strategy: avoid using qualifiers when possible.  
*Usually rare to have 2 beans of same type in ApplicationContext*



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## Java Config vs Annotations syntax

- Similar options are available



## Topics in this Session

- Fundamentals
  - Annotation-based Configuration
  - Best practices: when to use what?**
  - `@PostConstruct` and `@PreDestroy`
  - Stereotypes and meta annotations
- Lab
- Advanced features
  - `@Resource`
  - Standard annotations (JSR 330)



## About Component Scanning

- Components are scanned at startup
  - JAR dependencies also scanned!
  - Could result in slower startup time if too many files scanned
    - Especially for large applications
    - A few seconds slower in the worst case
- What are the best practices?



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## Best practices

- Really bad:  
`@ComponentScan ( { "org", "com" } )`

All “org” and “com”  
packages in the classpath  
will be scanned!!

- Still bad:  
`@ComponentScan ( "com" )`

- OK:  
`@ComponentScan ( "com.bank.app" )`

- Optimized:  
`@ComponentScan ( { "com.bank.app.repository",  
"com.bank.app.service", "com.bank.app.controller" } )`



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## When to use what?

Java

### Java Configuration

- Pros:
  - Is centralized in one (or a few) places
  - Write any Java code you need
  - Strong type checking enforced by compiler (and IDE)
  - Can be used for all classes (not just your own)
- Cons:
  - More verbose than annotations



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## When to use what?

@

### Annotations

- Nice for frequently changing beans
- Pros:
  - Single place to edit (just the class)
  - Allows for very rapid development
- Cons:
  - Configuration spread across your code base
    - Harder to debug/maintain
  - Only works for your own code
  - Merges configuration and code (bad sep. of concerns)



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## Mixing Java Config and Annotations

- You can mix and match in many ways
- Common approach:
  - Use annotations whenever possible
    - Your classes
  - But still use Java Configuration for
    - Third-party beans that aren't annotated
    - Legacy code that can't be changed



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## Topics in this Session

- Fundamentals
  - Annotation-based Configuration
  - Best practices: when to use what?
  - **@PostConstruct and @PreDestroy**
  - Stereotypes and meta annotations
- Lab
- Advanced features
  - **@Resource**
  - Standard annotations (JSR 330)



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## @PostConstruct and @PreDestroy

- Add behavior at startup and shutdown

```
public class JdbcAccountRepository {  
    @PostConstruct  
    void populateCache() {}  
  
    @PreDestroy  
    void clearCache() {}  
}
```

Method called at startup after dependency all injection

Method called at shutdown prior to destroying the bean instance



Annotated methods can have any visibility but *must* take *no* parameters and *only* return *void*



## About @PostConstruct & @PreDestroy

- Beans are created in the usual ways:
  - Returned from @Bean methods
  - Found and created by the component-scanner
- Spring then invokes these methods *automatically*
  - During bean-creation process
- These are not Spring annotations
  - Defined by JSR-250, part of Java since Java 6
  - In `javax.annotation` package
  - Supported by Spring, *and* by JEE



## @PostConstruct

- Called after setter methods are called

```
public class JdbcAccountRepository {  
    private DataSource dataSource;  
    @Autowired  
    public void setDataSource(DataSource dataSource)  
    { this.dataSource = dataSource; } 1  
  
    @PostConstruct  
    public void populateCache()  
    { Connection conn = dataSource.getConnection(); //... } 2  
}
```



## @PreDestroy

- Called when a *ConfigurableApplicationContext* is closed
  - If application (JVM) exits normally
  - Useful for releasing resources & 'cleaning up'
  - Not called for prototype beans

```
ConfigurableApplicationContext context = SpringApplication.run(...);  
// Triggers call of all @PreDestroy annotated methods  
context.close();
```

Causes Spring to invoke this method

```
public class JdbcAccountRepository {  
    @PreDestroy  
    public void clearCache() { ... }  
    ...  
}
```



## Lifecycle Methods via @Bean

- Alternatively, `@Bean` has options to define these *life-cycle* methods

```
@Bean (initMethod="populateCache", destroyMethod="clearCache")
public AccountRepository accountRepository() {
    // ...
}
```

- Common Usage:
  - `@PostConstruct/@PreDestroy` for your own classes
  - `@Bean` properties for classes you didn't write and can't annotate



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## Topics in this Session

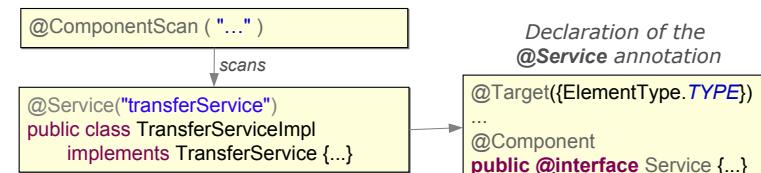
- Fundamentals
  - Annotation-based Configuration
  - Best practices: when to use what?
  - `@PostConstruct` and `@PreDestroy`
  - Stereotypes and meta annotations**
- Lab
- Advanced features
  - `@Resource`
  - Standard annotations (JSR 330)



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## Stereotype Annotations

- Component scanning also checks for annotations that are themselves annotated with @Component
  - So-called *sereotype annotations*



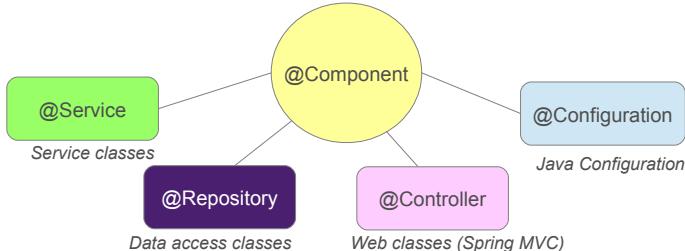
@Service annotation is part of the Spring framework



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## Predefined Stereotype Annotations

- Spring framework stereotype annotations



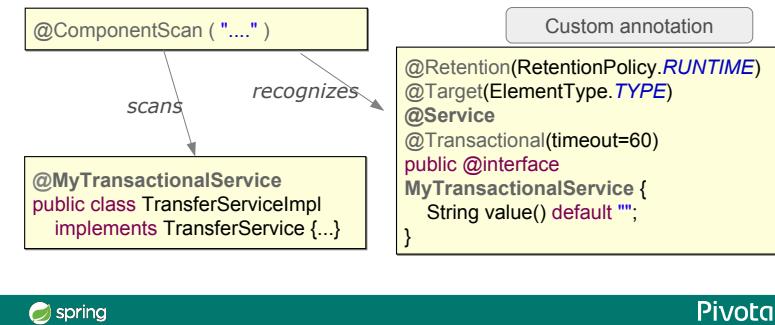
Other Spring projects provide their own stereotype annotations  
(Spring Web-Services, Spring Integration...)



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## Meta-annotations

- Annotation which can be used to annotate other annotations
  - e.g. all service beans should be configurable using component scanning and be transactional



spring

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## Summary

- Spring beans can be defined:
  - Explicitly using `@Bean` methods
  - Implicitly using `@Component` and component-scanning
- Most applications use both
  - Implicit for your classes
  - Explicit for the rest
- Can perform initialization and clean-up
  - Use `@PostConstruct` and `@PreDestroy`
- Use Spring's stereotypes and/or define your own meta annotations

spring

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# Lab

Using Spring Annotations  
To Configure and Test an application

**Coming Up:** Other Annotations for Dependency Injection



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## Topics in this Session

- Fundamentals
  - Annotation-based Configuration
  - Best practices: when to use what?
  - @PostConstruct and @PreDestroy
  - Stereotypes and meta annotations
- Lab
- Advanced features
  - **@Resource**
  - Standard annotations (JSR 330)



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## Using @Resource

- From JSR-250, supported by EJB 3.0 and Spring
  - Identifies dependencies by *name*, not by *type*
    - Name is Spring bean-name
    - @Autowired matches by *type*
  - Supports setter and field injection *only*

```
@Resource(name="jdbcAccountRepository")
public void setAccountRepository(AccountRepository repo) {
    this.accountRepository = repo;
}
```

Setter  
Injection

```
@Resource(name="jdbcAccountRepository")
private AccountRepository accountRepository;
```

Field  
injection



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## Qualifying @Resource

- @Autowired:** type *then* name
- When no name is supplied
  - Inferred from property/field name
  - Or falls back on injection by type
- Example
  - Looks for bean called *accountRepository*
    - because method is *setAccountRepository*
  - Then looks for bean of type *AccountRepository*

**@Resource:** name *then* type

```
@Resource
public void setAccountRepository(AccountRepository repo) {
    this.accountRepository = repo;
}
```



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## Topics in this Session

- Fundamentals
  - Annotation-based Configuration
  - Best practices: when to use what?
  - @PostConstruct and @PreDestroy
  - Stereotypes and meta annotations
- Lab
- Advanced features
  - @Resource
  - Standard annotations (JSR 330)



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## JSR 330

- Java Specification Request 330
  - Also known as @Inject
  - Joint JCP effort by Google and SpringSource
  - Standardizes internal DI annotations
  - Published late 2009
    - Spring is a valid JSR-330 implementation
- Subset of functionality compared to Spring's @Autowired support
  - @Inject has 80% of what you need
  - Rely on @Autowired for the rest



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## JSR 330 annotations

The diagram illustrates the relationship between Spring annotations and JSR 330 annotations. It shows two snippets of Java code: one for a service implementation and one for a repository.

**Annotations:**

- @ComponentScan ("....")**: A Spring annotation that also scans for JSR 330 annotations.
- @Inject**: A JSR 330 annotation used for dependency injection.
- @Named**: A JSR 330 annotation used for component naming.
- @Scope**: A JSR 330 annotation defining the scope of a bean.
- @Singleton**: A JSR 330 annotation indicating a single instance of a bean.
- @Value**: A Spring annotation for injecting values from configuration files.
- @Required**: A Spring annotation indicating a required dependency.
- @Lazy**: A Spring annotation indicating a lazily initialized dependency.

**Comments:**

- Also scans JSR-330 annotations**: Refers to the `@ComponentScan` annotation.
- Should be specified for component scanning (even without a name)**: Refers to the `@Named` annotation.

```
@ComponentScan ( "...." )
```

```
import javax.inject.Inject;
import javax.inject.Named;
```

```
@Named
public class TransferServiceImpl implements TransferService {
    @Inject
    public TransferServiceImpl( @Named("accountRepository")
        AccountRepository accountRepository) { ... }
}
```

```
import javax.inject.Named;

@Named("accountRepository")
public class JdbcAccountRepository implements
    AccountRepository {..}
```



## From `@Autowired` to `@Inject`

Spring	JSR 330	Comments
<code>@Autowired</code>	<code>@Inject</code>	<code>@Inject</code> always mandatory, has no required option
<code>@Component</code>	<code>@Named</code>	Spring also scans for <code>@Named</code>
<code>@Scope</code>	<code>@Scope</code>	JSR 330 Scope for meta-annotation and injection points only
<code>@Scope ("singleton")</code>	<code>@Singleton</code>	JSR 330 default scope is like Spring's 'prototype'
<code>@Qualifier</code>	<code>@Named</code>	
<code>@Value</code>	No equivalent	SpEL specific
<code>@Required</code>	Redundant	<code>@Inject</code> always required
<code>@Lazy</code>	No equivalent	Useful when needed, often abused



# Dependency Injection Using XML

Spring's XML Configuration Language

Using <bean> definitions and namespaces

## Topics in this session

- Writing bean definitions in XML
- Creating an application context
- Controlling Bean Behavior
- Factory Beans
- Namespaces
- Lab
- Advanced Topics

Note: XML is in the certification exam

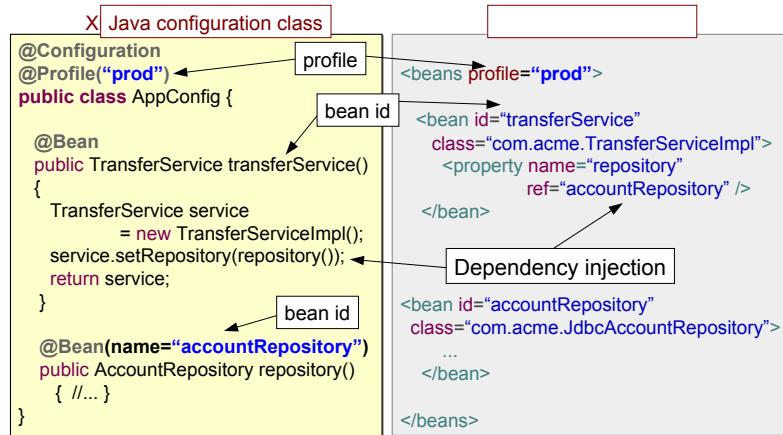


## XML Configuration

- Original form of Configuration / Dependency Injection
  - Dating back to before 2004
  - Still fully supported
- Most commonly seen in existing applications
  - ... and in older blogs, books, etc.
- External *explicit* configuration as with Java Config
  - Uses custom XML instead of Java



## @Configuration Comparison



## Constructor Injection Configuration

- One parameter

```
<bean id="transferService" class="com.acme.TransferServiceImpl">
    <constructor-arg ref="accountRepository"/>
</bean>

<bean id="accountRepository" class="com.acme.AccountRepositoryImpl"/>
```

- Multiple parameters

```
<bean id="transferService" class="com.acme.TransferServiceImpl">
    <constructor-arg ref="accountRepository"/>
    <constructor-arg ref="customerRepository"/>
</bean>

<bean id="accountRepository" class="com.acme.AccountRepositoryImpl"/>
<bean id="customerRepository" class="com.acme.CustomerRepositoryImpl"/>
```

Parameters injected according to their type



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## Constructor Injection 'Under the Hood'

```
<bean id="service" class="com.acme.ServiceImpl">
    <constructor-arg ref="repository"/>
</bean>

<bean id="repository" class="com.acme.RepositoryImpl"/>
```

Equivalent to:

```
@Bean public Repository repository() {
    return new RepositoryImpl();
}

@Bean public Service service() {
    return new ServiceImpl( repository() );
}
```



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## Setter Injection

```
<bean id="service" class="com.acme.ServiceImpl">
    <property name="repository" ref="repository"/>
</bean>
<bean id="repository" class="com.acme.RepositoryImpl"/>
```

Convention: implicitly refers to method `setRepository(...)`

Equivalent to:

```
@Bean public Repository repository() {
    return new RepositoryImpl();
}

@Bean public Service service() {
    Service svc = new ServiceImpl();
    svc.setRepository( repository() );
    return svc;
}
```



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## Combining Constructor and Setter Injection

```
<bean id="service" class="com.acme.ServiceImpl">
    <constructor-arg ref="required" />
    <property name="optional" ref="optional" />
</bean>

<bean id="required" class="com.acme.RequiredImpl" />
<bean id="optional" class="com.acme.OptionalImpl" />
```

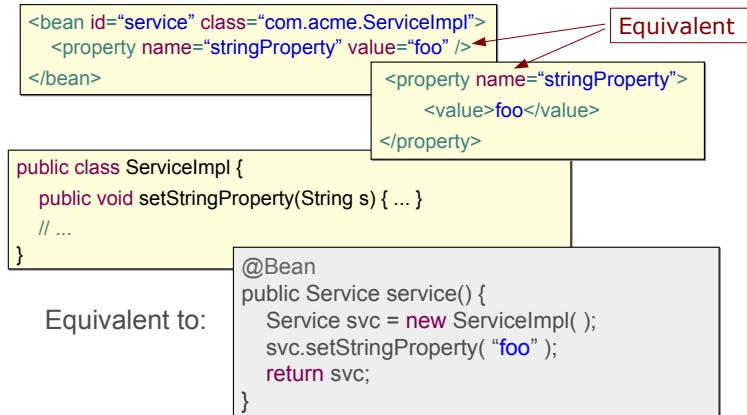
Equivalent to:

```
@Bean public RequiredImpl required() { ... }
@Bean public OptionalImpl optional() { ... }
@Bean public Service service() {
    Service svc = new ServiceImpl( required() );
    svc.setOptional( optional() );
    return svc;
}
```



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## Injecting Scalar Values



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## Automatic Value Type Conversion



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## Topics in this session

- Writing bean definitions in XML
- **Creating an application context**
- Controlling Bean Behavior
- Factory Beans
- Namespaces
- Lab
- Advanced Topics



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## Creating an ApplicationContext using XML

- Use a Java Configuration class
  - `@ImportResource` to define XML file(s):

```
SpringApplication.run(MainConfig.class);
```

```
@Configuration  
@ImportResource( {  
    "classpath:com/acme/application-config.xml",  
    "file:C:/Users/alex/application-config.xml" } )  
@Import(DatabaseConfig.class)  
public class MainConfig { ... }
```

- Multiple files possible.
- Valid prefixes are classpath: (default), file:, http:

Can combine with  
`@Configuration` imports



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## Remember @Import?

```
@Configuration  
@Import(DatabaseConfig.class)  
public class MainConfig {  
    ...  
}
```

- Use `<import />` to import other XML configuration files

```
<beans>  
    <import resource="db-config.xml" />  
</beans>
```

- Uses relative path by default
  - Same prefixes available (file, classpath, http)



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## Creating the ApplicationContext – I

- So far, you have seen the ApplicationContext created like this:

```
ApplicationContext context = new MainConfig().getApplicationContext();
```

- This is actually a Spring Boot class
  - But it works well for *any* Spring application
  - More general purpose than previous alternatives



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## Creating the ApplicationContext

- Older “classic” techniques available as well
  - Context type defines *where* XML files are loaded from
  - Existing code (and many online examples) do it this way

```
// Load Java Configuration class  
new AnnotationConfigApplicationContext(MainConfig.class);  
  
// Load from $CLASSPATH/com/acme/application-config.xml  
new ClassPathXmlApplicationContext("com/acme/application-config.xml");  
  
// Load from absolute path: C:/Users/alex/application-config.xml  
new FileSystemXmlApplicationContext("C:/Users/alex/application-config.xml");  
  
// Load from path relative to the JVM working directory  
new FileSystemXmlApplicationContext("./application-config.xml");
```



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## Topics in this session

- Writing bean definitions
- Creating an application context
- **Controlling Bean Behavior**
- Factory Beans
- Namespaces
- Lab
- Advanced Topics



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## Remember @PostConstruct?

```
@PostConstruct  
public void setup() {  
    ...  
}
```

- Same option available in XML
  - But called “init-method”:

```
<bean id="accountService" class="com.acme.ServiceImpl" init-method="setup">  
    ...  
</bean>
```



Same rules: method can have any visibility, *must* take *no* parameters, must return *void*. Called after dependency injection.



## Remember @PreDestroy?

```
@PreDestroy  
public void teardown() {  
    ...  
}
```

- Same option available in XML
  - But called “destroy-method”:

```
<bean id="Service" class="com.acme.ServiceImpl" destroy-method="teardown">  
    ...  
</bean>
```



Same rules: method can have any visibility, *must* take *no* parameters, must return *void*.



## Remember Bean Scope?

```
@Bean  
@Scope("prototype")  
public AccountService accountService() {  
    return ...  
}  
  
@Component  
@Scope("prototype")  
public class AccountServiceImpl {  
    ...  
}
```

- Same options available in XML
  - singleton, prototype, request, session, (custom)

```
<bean id="accountService" class="com.acme.ServiceImpl" scope="prototype">  
    ...  
</bean>
```



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## Remember @Lazy?

```
@Bean  
@Lazy("true")  
public AccountService accountService() {  
    return ...  
}  
  
@Component  
@Lazy()  
public class AccountServiceImpl {  
    ...  
}
```

- Same option available in XML
  - Still not recommended, often misused

```
<bean id="accountService" class="com.acme.ServiceImpl" lazy-init="true">  
    ...  
</bean>
```



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## Profile Configuration in XML

- All bean definitions

```
<beans xmlns="http://www.springframework.org/schema/beans ...  
    profile="dev"> ... </beans>
```

Profile applies to *all*  
Beans in the file

- Subset of bean definitions

```
<beans xmlns="http://www.springframework.org/schema/beans ...>  
    <bean id="rewardNetwork" ... /> <!-- Available to all profiles -->  
    ...  
    <beans profile="dev"> ... </beans>  
    <beans profile="prod"> ... </beans>  
</beans>
```

Different subset  
of beans for each  
profile, plus some  
shared beans



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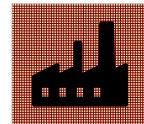
## Topics in this session

- Writing bean definitions in XML
- Creating an application context
- Controlling Bean Behavior
- Factory Beans**
- Namespaces
- Lab



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## Advanced XML Bean Instantiation



- Conditional configuration
  - @Bean methods can use *any* Java you need
    - Do property lookups
    - Use if-then-else and iterative logic
- No equivalent in XML
  - We did *not* implement <if>, <for-each>
- Instead Spring XML relies on the *Factory Pattern*
  - Use a factory to create the bean(s) we want
  - Use *any* complex Java code we need in the factory's internal logic



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## The Spring FactoryBean interface



- Fall-back for complex configuration in XML

— Used long before @Bean methods introduced

```
public class AccountServiceFactoryBean  
    implements FactoryBean<AccountService>  
{  
    public AccountService getObject() throws Exception {  
        // Conditional logic – for example: selecting the right  
        // implementation or sub-class of AccountService to create  
        return accountService;  
    }  
  
    public boolean isSingleton() { return true; }  
    public Class<?> getObjectType() { return AccountService.class; }  
}  
<bean id="accountService" class="com.acme.AccountServiceFactoryBean" />
```

**Note:** even Java Configuration may use factory beans



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## The FactoryBean interface

- Beans implementing *FactoryBean* are *auto-detected*
- Dependency injection using the factory bean id causes *getObject()* to be invoked transparently

```
<bean id="accountService"
      class="com.acme.AccountServiceFactoryBean"/>

<bean id="customerService" class="com.acme.CustomerServiceImpl">
    <property name="service" ref="accountService" />
</bean>
```

*getObject() called by  
Spring internally*



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## Using FactoryBeans with Java Configuration

- Works exactly the same way

```
@Configuration
public class ServiceConfig {

    @Bean
    public AccountServiceFactoryBean accountService() {
        return new AccountServiceFactoryBean();
    }

    @Bean
    public CustomerService customerService(AccountService accountService) {
        return new CustomerService(accountService);
    }
}
```

*getObject() called by  
Spring internally*



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## FactoryBeans in Spring

- FactoryBeans are widely used within Spring
  - EmbeddedDatabaseFactoryBean\*\*
  - JndiObjectFactoryBean
    - One option for looking up JNDI objects
  - Creating Remoting proxies
  - Creating Caching proxies\*\*
  - For configuring data access technologies\*\*
    - JPA, Hibernate or MyBatis
- In XML, often hidden behind *namespaces*

\*\* These will appear later in the course



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## Topics in this session

- Writing bean definitions in XML
- Creating an application context
- Controlling Bean Behavior
- Factory Beans
- **Namespaces**
- Lab



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## Default Namespace

- The default namespace in a Spring configuration file is typically the “beans” 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"
       xsi:schemaLocation="
           http://www.springframework.org/schema/beans
           http://www.springframework.org/schema/beans/spring-beans.xsd>
    <!-- ... -->
</beans>
```



dozens of other namespaces are available!



## Other Namespaces

- Defined for subsets of framework functionality\*
  - aop (Aspect Oriented Programming)
  - tx (transactions)
  - util
  - jms
  - context
  - ...
- They allow hiding of actual bean definitions
  - Define “programming instructions” for bean files
  - Greatly reduce size of bean files (see next slides)



See <http://www.springframework.org/schema/> for complete list



# Namespace Example 1

## In-Memory DataStore using Bean XML

- Creating an in-memory test database

```
<bean id="dataSource" class="org.springframework.jdbc.datasource.  
    embedded.EmbeddedDatabaseFactoryBean">  
    <property name="databasePopulator" ref="populator"/>  
</bean>  
  
<bean id="populator" class="org.springframework.jdbc.datasource.  
    init.ResourceDatabasePopulator">  
    <property name="scripts">  
        <list>  
            <value>classpath:rewards/testdb/schema.sql</value>  
            <value>classpath:rewards/testdb/data.sql</value>  
        </list>  
    </property>  
</bean>
```

FactoryBean

Populate with  
test-data

Bean XML requires two beans and  
knowledge of the classes being used



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# Namespace Example 1

## In-Memory DataStore using jdbc Namespace

- Simplify using jdbc namespace

```
<jdbc:embedded-database type="HSQL" id="dataSource">  
    <jdbc:script location="classpath:rewards/testdb/schema.db"/>  
    <jdbc:script location=""classpath:rewards/testdb/test-data.db""/>  
</jdbc:embedded-database>
```

Equivalent to ...

```
@Bean public DataSource dataSource() {  
    EmbeddedDatabaseBuilder builder = new EmbeddedDatabaseBuilder();  
    return builder.setName("testdb")  
        .setType(EmbeddedDatabaseType.HSQL)  
        .addScript("classpath:rewards/testdb/schema.db")  
        .addScript("classpath:rewards/testdb/test-data.db").build();  
}
```



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## Namespace Example 2

### Property Placeholders

- Property Placeholders define property sources
  - XML Equivalent of @PropertySource
- Namespace just an elegant way to hide the underlying bean declaration
  - Same functionality, less typing

```
<context:property-placeholder location="db-config.properties" />
```



```
<bean class="org.springframework...PropertySourcesPlaceholderConfigurer">
    <property name="location" value="db-config.properties"/>
</bean>
```



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## Accessing Properties in XML

```
<beans ...>
    <context:property-placeholder location="db-config.properties" />

    <bean id="dataSource" class="com.oracle.jdbc.pool.OracleDataSource">
        <property name="URL" value="${dbUrl}" />
        <property name="user" value="${dbUserName}" />
    </bean>
</beans>
```



dbUrl=jdbc:oracle:...  
dbUserName=moneytransfer-app

db-config.properties



```
<bean id="dataSource"
      class="com.oracle.jdbc.pool.OracleDataSource">
    <property name="URL" value="jdbc:oracle:..." />
    <property name="user" value="moneytransfer-app" />
</bean>
```



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## XML Profiles and Properties

```
<import resource="classpath:config/${current.env}-config.xml"/>
<context:property-placeholder properties-ref="configProps"/>
{<beans profile="dev">
    <util:properties id="configProps" location="config/app-dev.properties">
</beans>
<beans profile="prod">
    <util:properties id="configProps" location="config/app-prod.properties">
</beans>
```

current.env=dev  
database.url=jdbc:derby:/test  
database.user=tester

current.env=prod  
database.url=jdbc:oracle:thin:...  
database.user=admin

Equivalent to ...

```
@PropertySource ( "classpath:/com/acme/config/app-${ENV}.properties" )
```



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## Typical Profiles & Namespaces Example

```
<beans xmlns="http://www.springframework.org/schema/beans"
       xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
       xmlns:jdbc="http://www.springframework.org/schema/jdbc"
       xmlns:jee="http://www.springframework.org/schema/jee"
       xsi:schemaLocation="...">
    <beans profile="dev">
        <jdbc:embedded-database id="dataSource">
            <jdbc:script location="classpath:com/bank/sql/schema.sql"/>
            <jdbc:script location="classpath:com/bank/sql/test-data.sql"/>
        </jdbc:embedded-database>
    </beans>
    <beans profile="production">
        <jee:jndi-lookup id="dataSource" jndi-name="java:comp/env/jdbc/datasource" />
    </beans>
</beans>
```



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## Power of Namespaces

- Greatly simplifies Spring configuration
  - Many advanced features of Spring need to declare a large number of beans

```
<?xml version="1.0" encoding="UTF-8"?>
<beans ...>
    <context:property-placeholder location="db-config.properties" />
        ↗ hides 1 bean definition
    <aop:aspectj-autoproxy /> ← AOP configuration: hides 5+ bean definitions
    <tx:annotation-driven /> ← Transactions configuration: hides more than 15 bean definitions!
</beans>
```



Transactions and AOP will be discussed later



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## Remember @ComponentScan?

```
@Configuration
@ComponentScan ( { "com.acme.app.repository",
    "com.acme.app.service", "com.acme.app.controller" }
public class MainConfig {
    ...
}
```

- Available in the context namespace

```
<context:component-scan base-package="com.acme.app.repository,
    com.acme.app.service, com.acme.app.controller" />
```

Single String



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## Namespaces Declarations are Tedium!

- What you need for beans, context and jdbc:

```
<beans xmlns="http://www.springframework.org/schema/beans"
       xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
       xmlns:jdbc="http://www.springframework.org/schema/jdbc"
       xmlns:context="http://www.springframework.org/schema/context"
       xsi:schemaLocation="http://www.springframework.org/schema/beans
                           http://www.springframework.org/schema/beans/spring-beans.xsd
                           http://www.springframework.org/schema/jdbc
                           http://www.springframework.org/schema/jdbc/spring-jdbc.xsd
                           http://www.springframework.org/schema/context
                           http://www.springframework.org/schema/context/spring-context.xsd">
```

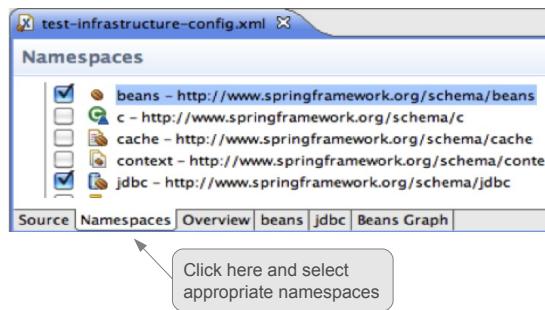
- A typo waiting to happen!
  - Fortunately there is an easier way ... (next slide)



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## Adding namespace declaration

- XML syntax is error-prone
  - Use the dedicated STS XML editor Namespaces tab!



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## Schema Version Numbers

[spring-beans-4.2.xsd](#) OR [spring-beans.xsd](#) ?

- Common practice: *do not* use a version number
  - Triggers use of most recent schema version
  - Easier migration
    - Will make it easier to upgrade to the next version of Spring

```
<?xml version="1.0" encoding="UTF-8"?>
<beans xmlns="http://www.springframework.org/schema/beans"
       xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
       xsi:schemaLocation="
           http://www.springframework.org/schema/beans
           http://www.springframework.org/schema/beans/spring-beans-4.2.xsd">
    <!-- ... -->
</beans>
```

Not needed!



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## Summary

- Spring's XML definition language provides *explicit* bean definitions using `<bean>` syntax
  - Pre-dates Java Configuration
  - Provides many of the same options via attributes
- Factory Beans
  - Important configuration device
  - Understand how `getObject()` works
- Namespaces reduce verbosity, hide internal details



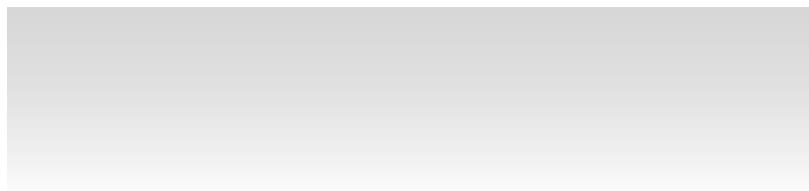
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# Spring XML Best Practices

- XML has been around for a long time
  - Many shortcuts and useful techniques exist
    - Singleton and Factory Beans
    - Bean Definition Inheritance
    - Inner Beans
    - p and c namespaces
    - Using collections as Spring beans
- Optional Section at back of handout
  - **XML Dependency Injection Best Practices**
    - Optional lab also



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## Lab (optional)

Using XML to Configure an Application



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# Understanding the Bean Lifecycle

An In-Depth Look “Under the Hood”

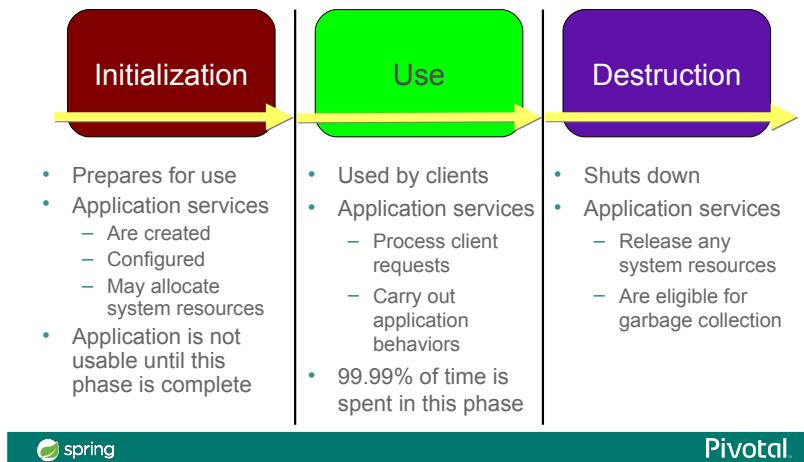
Using Bean Pre- and Post-Processors

## Topics in this session

- **Introduction**
- The initialization phase
- The use phase
- The destruction phase

The content of this chapter is a *much simplified* view of Spring's inner workings

## Phases of the Application Lifecycle



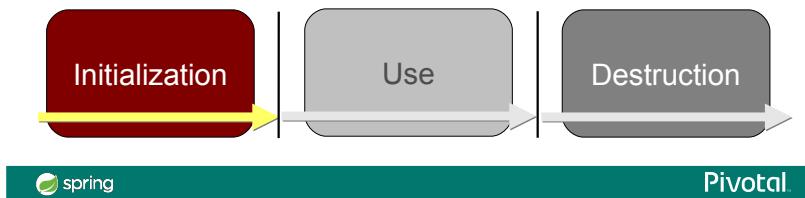
## Spring's Role as a Lifecycle Manager

- Spring fits in to manage your application lifecycle
  - May play an important role in *all* phases
- Lifecycle applies to
  - Any class of application
    - Standalone Java or Spring Boot application
    - Integration/System Test
    - Java EE™ (web or full profile)
  - All 3 dependency injection styles
    - XML, annotations and Java Configuration



## Topics in this session

- Introduction
- **The initialization phase**
- The use phase
- The destruction phase



## Lifecycle of a Spring Application Context (1) *The Initialization Phase*

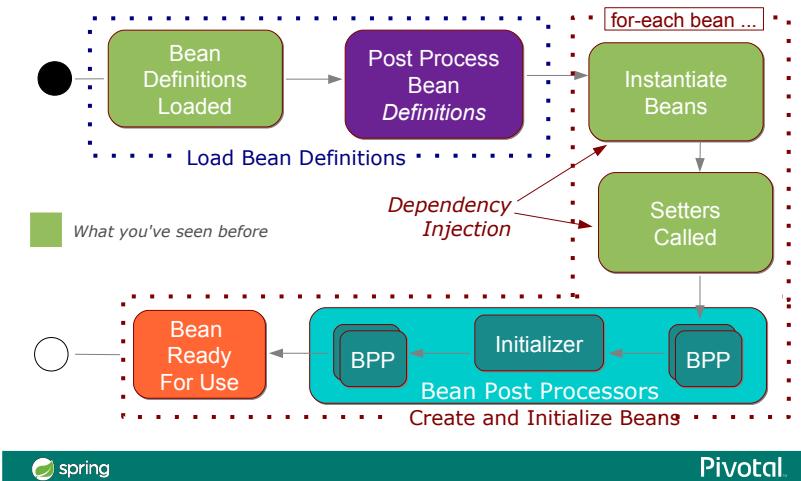
- When a context is created the initialization phase completes

```
// Create the application from the configuration
ApplicationContext context =
    SpringApplication.run(AppConfig.class);
```

- But what exactly happens in this phase?

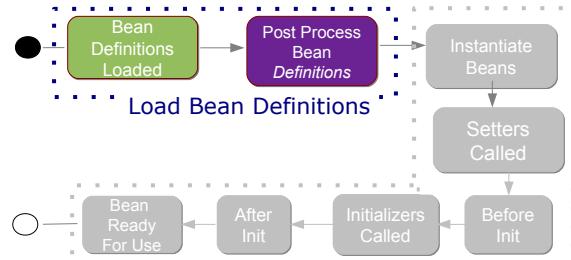


## Bean Initialization Steps



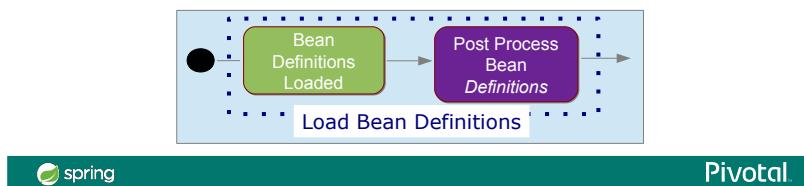
## Inside The Application Context – Initialization Lifecycle (1)

- Load bean definitions
- Initialize bean instances



## Load Bean Definitions

- The `@Configuration` classes are processed
  - And/or `@Components` are scanned for
  - And/or XML files are parsed
- Bean definitions added to a `BeanFactory`
  - Each indexed under its id
- Special `BeanFactoryPostProcessor` beans invoked
  - Can modify the *definition* of *any* bean



## Load Bean Definitions

AppConfig.java

```
@Bean  
public TransferService transferService() { ... }  
@Bean  
public AccountRepository  
accountRepository() { ... }
```

TestInfrastructureConfig.java

```
@Bean  
public DataSource dataSource () { ... }
```

ApplicationContext

BeanFactory  
transferService  
accountRepository  
dataSource

postProcess(BeanFactory)

Can modify the definition of  
any bean in the factory  
before any objects are created

BeanFactoryPostProcessors



## *BeanFactoryPostProcessor* Extension Point

- Applies transformations to bean *definitions*
  - Before objects are actually created
- Several useful implementations provided in Spring
  - Reading properties, registering a custom scope ...
- You can write your own (not common)
  - Implement **BeanFactoryPostProcessor** interface

```
public interface BeanFactoryPostProcessor {  
    public void postProcessBeanFactory  
        (ConfigurableListableBeanFactory beanFactory);  
}
```



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## Most Common Example of Using a **BeanFactoryPostProcessor**

- Recall @Value and \${...} variables
  - Need a **PropertySourcesPlaceholderConfigurer** to evaluate them
  - *This is a BeanFactoryPostProcessor*

```
@Configuration  
@PropertySource ( "classpath:/config/app.properties" )  
public class ApplicationConfig {  
  
    @Value("${max.retries}")  
    int maxRetries;  
  
    ...  
}
```



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## Java Configuration uses *Static* beans

- To ensure these beans are created *without side-effects*, they must be defined as *static* methods
- Example:

— `PropertySourcesPlaceholderConfigurer`

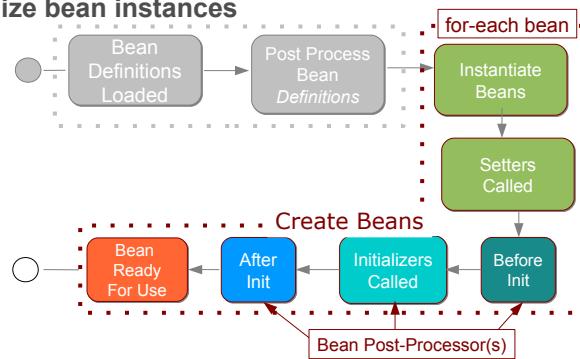
```
@Bean  
public static PropertySourcesPlaceholderConfigurer  
    propertySourcesPlaceholderConfigurer() {  
    return new PropertySourcesPlaceholderConfigurer();  
}
```

Or if using XML, `<context:property-placeholder/>` creates a `PropertySourcesPlaceholderConfigurer` for you



## Inside the Application Context – Initialization Lifecycle (2)

- Load bean definitions
- **Initialize bean instances**



## Bean Creation Summary

- Each bean is eagerly instantiated by default
  - Created in right order with its dependencies injected
    - Unless marked as lazy
- Next each bean goes through a *post-processing* phase
  - *BeanPostProcessors*
- Now the bean is fully initialized and ready for use
  - Tracked by its id until the context is destroyed
    - Except prototype beans



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## The Initializer Extension Point

- Special case of a bean post-processor
  - Causes init (@PostConstruct) methods to be called
- Internally Spring uses several BPPs
  - *CommonAnnotationBeanPostProcessor* enables initialization



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## The Initializer Extension Point - XML

- BPPs must be enabled when using *just* XML
  - Specify either `<context:annotation-config/>`
  - Or `<context:component-scan/>`
- Either enables same BPPs

```
<bean id="accountRepository" class="com.acme.JdbcAccountRepo"
      init-method="populateCache">
    ...
</bean>

<context:annotation-config/>
```

*init-method ignored unless explicitly enabled*



## The BeanPostProcessor Extension Point



- An important extension point in Spring
  - Can modify bean *instances* in any way
  - *Powerful* enabling feature
- Must implement the `BeanPostProcessor` interface
  - Spring provides several implementations
  - You can write your own (not common)

*Course will show several BPPs*

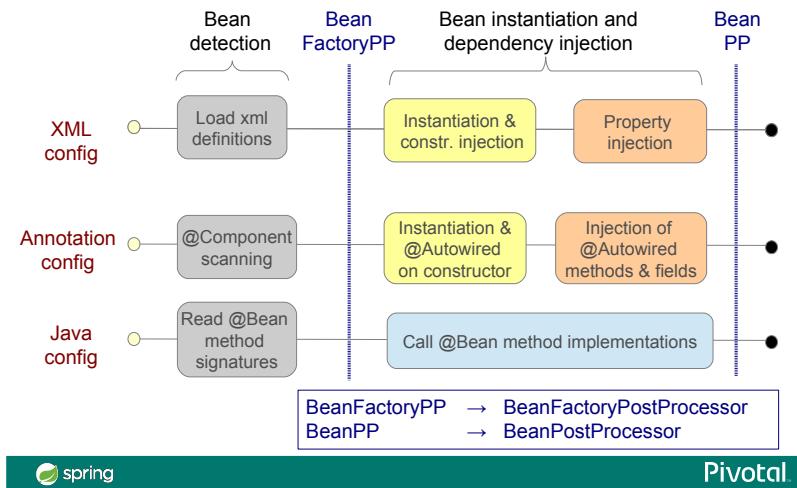
```
public interface BeanPostProcessor {
    public Object postProcessAfterInitialization(Object bean, String beanName);
    public Object postProcessBeforeInitialization(Object bean, String beanName);
}
```

Post-processed bean

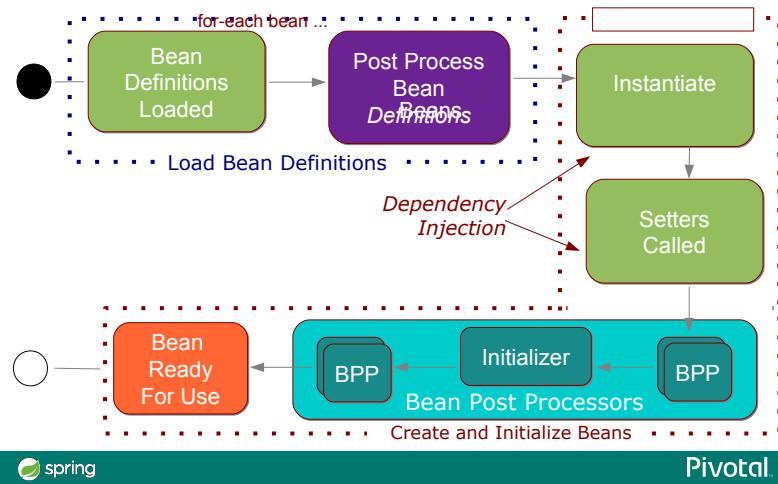
Original bean



## Configuration Lifecycle

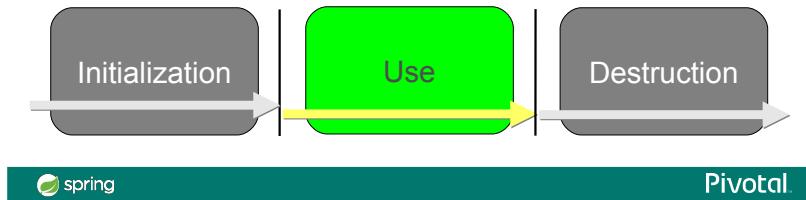


## The Full Initialization Lifecycle



## Topics in this session

- Introduction
- The initialization phase
- **The use phase**
- The destruction phase



## Lifecycle of a Spring Application Context (2) The Use Phase

- When you invoke a bean obtained from the context the application is used

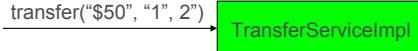
```
ApplicationContext context = // get it from somewhere
// Lookup the entry point into the application
TransferService service =
    (TransferService) context.getBean("transferService");
// Use it!
service.transfer(new MonetaryAmount("50.00"), "1", "2");
```

- But exactly what happens in this phase?

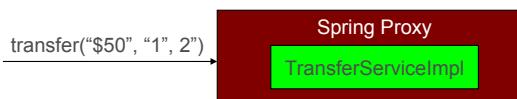


## Inside The Bean Request (Use) Lifecycle

- The bean is just your raw object
  - it is simply invoked directly (nothing special)



- Your bean has been wrapped in a *proxy*
  - things become more interesting



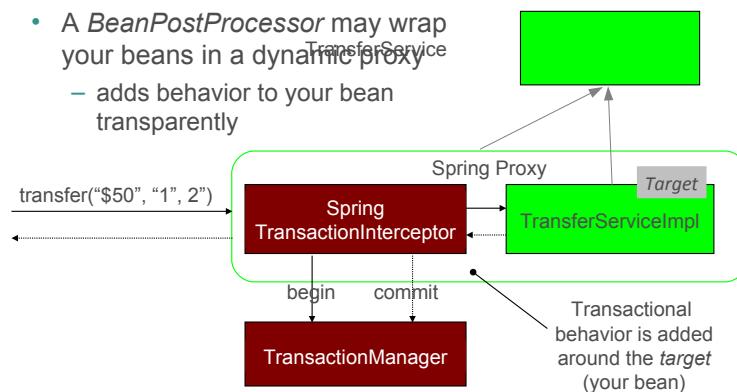
Proxy classes are created in the init phase by dedicated  
BeanPostProcessors

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## Proxy Power

- A *BeanPostProcessor* may wrap your beans in a *dynamic proxy*
  - adds behavior to your bean transparently



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## Kinds of Proxies

- Spring will create either JDK or CGLib proxies

### JDK Proxy

- Also called *dynamic* proxies
- API is built into the JDK
- Requirements: Java interface(s)
- All interfaces proxied

### CGLib Proxy

- NOT built into JDK
- Included in Spring jars
- Used when interface not available
- Cannot be applied to final classes or methods



Recommendation: Code to interfaces / Use JDK proxies (default)

[See Spring Reference - 10.5.3 JDK- and CGLIB-based proxies](#)

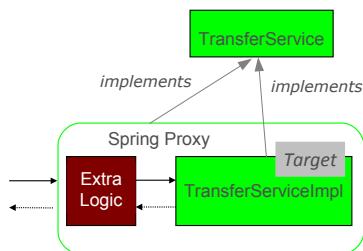


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## JDK vs CGLib Proxies

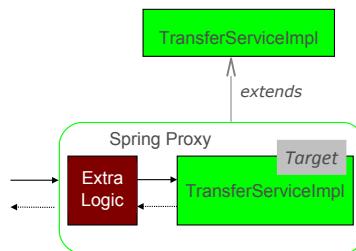
- JDK Proxy

- Interface based



- CGLib Proxy

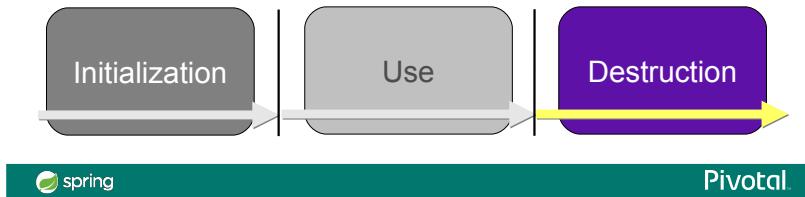
- subclass based



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## Topics in this session

- Introduction
- The initialization phase
- The use phase
- **The destruction phase**



## Lifecycle of a Spring Application Context (3) The Destruction Phase

- When you close a context the destruction phase completes

```
// Need a configurable ApplicationContext
ConfigurableApplicationContext context =
    SpringApplication.run( AppConfig.class );

// Destroy the application
context.close();
```

- *But exactly what happens in this phase?*



## ApplicationContext Destruction Lifecycle (1)

- Destroy bean instances if instructed
  - Call their destroy (clean-up) methods
  - Beans must have a *destroy method* defined
    - A no-arg method returning void
- Context then destroys (cleans-up) itself
  - The context is not usable again

**Remember:**  
only GC actually  
destroys objects

```
@Bean (destroyMethod="clearCache")  
public AccountRepository accountRepository() {  
    // ...  
}
```

A method on the  
AccountRepository



- Called only when ApplicationContext / JVM exit *normally*
- Not called for *prototype* beans

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## ApplicationContext Destruction Lifecycle (2)

- Can do the same using XML or annotations
  - Annotations require ~~the annotation config~~ scanner to be activated

*Using XML*

```
<bean id="accountRepository"  
      class="app.impl.AccountRepository"  
      destroy-method="clearCache">  
    ...  
</bean>
```

*By Annotation*

```
public class AccountRepository {  
  
    @PreDestroy  
    void clearCache() {  
        // close files, connections ...  
        // remove external resources ...  
    }  
}
```

```
<context:annotation-config/>
```

```
<context:component-scan ... />
```

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## Topics Covered

- Spring Lifecycle
  - The initialization phase
    - Bean Post Processors for *initialization* and *proxies*
  - The use phase
    - Proxies at Work – most of Spring's “magic” uses a proxy
  - The destruction phase
    - Allow application to terminate cleanly



# Testing Spring Applications

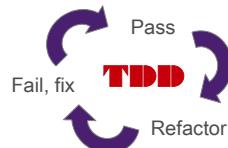
Unit Testing without Spring  
Integration Testing with Spring

Testing in General, Spring and JUnit,  
Profiles, Database Testing

## Topics in this Session

- **Test Driven Development**
- Integration Testing with Spring
- Testing with Profiles
- Testing with Databases
- Lab
- Appendix on Unit Testing (Stubs & Mocks)

## What is TDD?



- TDD = Test Driven Development
  - Is it writing tests before the code?
  - Is it writing tests at the same time as the code?
  - Ultimately that is not what is most important
- TDD is about:
  - Writing automated tests that verify code actually works
  - Driving development with well defined requirements in the form of tests



*“But We Don’t Have Time to Write Tests!”*

- Every development process includes testing
  - Either automated or manual
- Automated tests result in a faster development cycle overall
  - Your IDE is better at this than you are
- Properly done TDD is faster than development without tests



## TDD and Agility

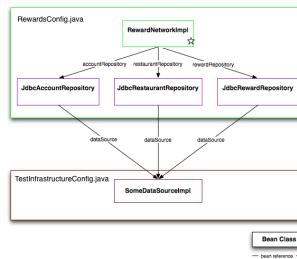


- Comprehensive test coverage provides confidence
- Confidence enables refactoring
- Refactoring is essential to agile development



## TDD and Design

- Testing makes you think about your design
- If your code is hard to test then the design should be reconsidered



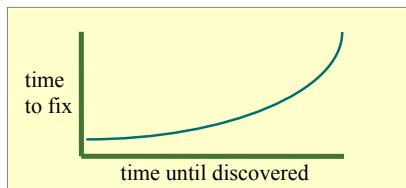
## TDD and Focus

- A test case helps you focus on what matters
- It helps you not to write code that you don't need
- Find problems early



## Benefits of Continuous Integration

- The cost to fix a bug grows exponentially in proportion to the time before it is discovered



- Continuous Integration (CI) focuses on reducing the time before the bug is discovered
  - Effective CI requires automated tests

## Topics in this Session

- Test Driven Development
- **Integration Testing with Spring**
- Testing with Profiles
- Testing with Databases
- Lab
- Appendix on Unit Testing (Stubs & Mocks)



### Unit Testing

### Unit Testing *Without Spring*

- Unit Testing
  - Tests one unit of functionality
  - Keeps dependencies minimal
  - Isolated from the environment (including Spring)
  - Uses simplified alternatives for dependencies
    - Stubs and/or Mocks
    - See *Appendix for more details*



# Integration Testing

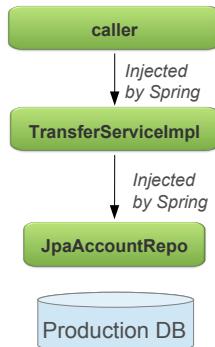
## Integration Testing With Spring

- Integration (System) Testing
  - Tests the interaction of multiple units working together
    - All should work individually (unit tests showed this)
- Tests application classes in context of their surrounding infrastructure
  - Out-of-container testing, no need to run up full JEE system
  - Infrastructure may be “scaled down”
    - Use Apache DBCP connection pool instead of container-provider pool obtained through JNDI
    - Use ActiveMQ to save expensive commercial JMS licenses

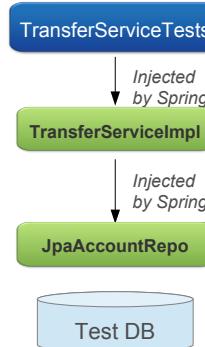


## Integration test example

- Production mode



- Integration test



## Spring's Integration Test Support

- Packaged as a separate module
  - spring-test.jar
- Consists of several JUnit test support classes
- Central support class is *SpringJUnit4ClassRunner*
  - Caches a *shared* ApplicationContext across test methods



See: Spring Framework Reference – Integration Testing

<http://docs.spring.io/spring/docs/current/spring-framework-reference/htmlsingle/#integration-testing>



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## Using Spring's Test Support

```
Run with Spring support → @RunWith(SpringJUnit4ClassRunner.class)  
                                @ContextConfiguration(classes=SystemTestConfig.class)  
  
public final class TransferServiceTests {  
    @Autowired ← Inject bean to test  
    private TransferService transferService;  
  
    @Test  
    public void shouldTransferMoneySuccessfully() {  
        TransferConfirmation conf = transferService.transfer(...);  
        ...  
    } → Test the system as normal  
}  
No need for @Before method
```



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## Including Configuration as an inner class

```
@RunWith(SpringJUnit4ClassRunner.class)
@ContextConfiguration
public class JdbcAccountRepoTest {

    private JdbcAccountRepo repo = ...;

    @Test
    public void shouldUpdateDatabaseSuccessfully() {...}

    | @Configuration
    | @Import(SystemTestConfig.class)
    | static class TestConfiguration {
    |     @Bean public DataSource dataSource() { ... }
    | }
}
```

**Don't specify config classes**

**Looks for configuration embedded in the class**

**Override a bean with a test alternative**



## @ContextConfiguration – XML

- Tests when using XML based configuration

```
@RunWith(SpringJUnit4ClassRunner.class)
@ContextConfiguration("classpath:com/acme/system-test-config.xml")
public final class TransferServiceTests { ... }
```

```
@RunWith(SpringJUnit4ClassRunner.class)
@ContextConfiguration({"classpath:config-1.xml", "file:db-config.xml"})
public final class TransferServiceTests { ... }
```

```
@RunWith(SpringJUnit4ClassRunner.class)
@ContextConfiguration
public class TransferServiceTests { ... }
```

**Defaults to \${classname}-context.xml in same package**

**Loads TransferServiceTests-context.xml**



## Multiple test methods

```
@RunWith(SpringJUnit4ClassRunner.class)
@ContextConfiguration(classes=SystemTestConfig.class)
public final class TransferServiceTests {
    @Autowired
    private TransferService transferService;

    @Test
    public void successfulTransfer() {
        ...
    }

    @Test
    public void failedTransfer() {
        ...
    }
}
```

The ApplicationContext is instantiated only *once* for all tests that use the same set of config files (even across test classes)



Annotate test method with `@DirtiesContext` to force recreation of the cached ApplicationContext if method changes the contained beans



## Test Property Sources

- Custom properties *just* for testing
  - Specify one or more properties
    - Will override any existing properties of same name
  - Specify location of one or more properties files to load
    - Defaults to looking for `[classname].properties`

```
@RunWith(SpringJUnit4ClassRunner.class)
@ContextConfiguration(classes=SystemTestConfig.class)
@TestPropertySource(properties = { "username=foo", "password=bar" }
    locations = "classpath:/transfer-test.properties")
public final class TransferServiceTests {
    ...
}
```



## Spring 4.3 Simplification

Spring 4.3

- Can use `SpringRunner` as an alternative to the `SpringJUnit4ClassRunner`
  - Simply a sub-class with a nicer name

```
@RunWith(SpringRunner.class)
@ContextConfiguration(classes=SystemTestConfig.class)
public final class TransferServiceTests {
    ...
}
```



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## Benefits of Testing with Spring

- No need to deploy to an external container to test application functionality
  - Run everything quickly inside your IDE
  - Supports *Continuous Integration* testing
- Allows reuse of your configuration between test and production environments
  - Application configuration logic is typically reused
  - Infrastructure configuration is environment-specific
    - DataSources
    - JMS Queues



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## Topics in this Session

- Test Driven Development
- Integration Testing with Spring
- **Testing with Profiles**
- Testing with Databases
- Lab
- Appendix on Unit Testing (Stubs & Mocks)



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## Activating Profiles For a Test

- **@ActiveProfiles** inside the test class
  - Define one or more profiles
  - Beans associated with that profile are instantiated
  - Also beans not associated with *any* profile
- Example: Two profiles activated – **jdbc** and **dev**

```
@RunWith(SpringJUnit4ClassRunner.class)
@ContextConfiguration(classes=DevConfig.class)
@ActiveProfiles({ "jdbc", "dev" })

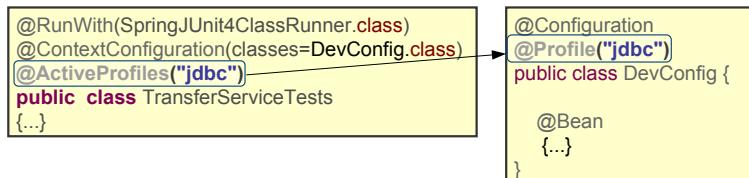
public class TransferServiceTests { ... }
```



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## Profiles Activation with JavaConfig

- **@ActiveProfiles** inside the test class
- **@Profile** inside the **@Configuration** class

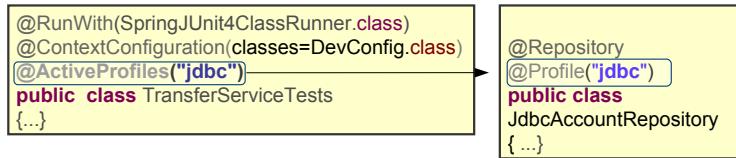


Remember: only @Configurations matching an active profile or with no profile are loaded



## Profiles Activation with Annotations

- **@ActiveProfiles** inside the test class
- **@Profile** inside the Component class

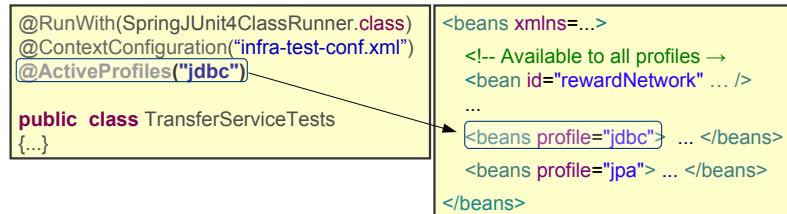


Only beans with current profile / no profile are component-scanned



## Profiles Activation with XML

- **@ActiveProfiles** inside the test class
- **profile** attribute inside **<bean>** tag



Only beans with current profile / no profile are loaded



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## Topics in this Session

- Test Driven Development
- Integration Testing with Spring
- Testing with Profiles
- **Testing with Databases**
- Lab
- Appendix on Unit Testing (Stubs & Mocks)



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## Testing with Databases

- Integration testing against SQL database is common.
- In-memory databases useful for this kind of testing
  - No prior install needed
- Common requirement: populate DB before test runs
  - Use the `@Sql` annotation:

```
@Test
@Sql ( "/testfiles/test-data.sql" ) ← Run this SQL command
public void successfulTransfer() { ← Before this test method executes.
    ...
}
```



See: Spring Framework Reference, Executing SQL Scripts

<http://docs.spring.io/spring/docs/current/spring-framework-reference/htmlsingle/#testcontext-executing-sql>



## @Sql Examples

```
Run these scripts before
@.RunWith(SpringJUnit4ClassRunner.class)
@ContextConfiguration(...)
@Sql( { "/testfiles/schema.sql", "/testfiles/general-data.sql" } ) ← each @Test method

public final class MainTests {
    ...
    @Test
    @Sql( { "/testfiles/error.sql" } ) ← Run script named (by default)
    public void success() { ... } ← MainTests.success.sql
                                         in same package
                                         ← Run before @Test method...
                                         ...run after @Test method
    ...
    @Test
    @Sql( { "scripts= /testfiles/cleanup.sql", "executionPhase=Sql.ExecutionPhase.AFTER_TEST_METHOD" } )
    public void transferError() { ... }
}
```



## @Sql Options

- When does the SQL run?
  - `executionPhase`: before (default) or after the test method
  - `config`: SqlConfig has many options to control SQL scripts
    - What to do if script fails? `FAIL_ON_ERROR`,  
`CONTINUE_ON_ERROR`, `IGNORE_FAILED_DROPS`, `DEFAULT*`
    - SQL syntax control: comments, statement separator

```
@Sql( scripts = "/test-user-data.sql",
       executionPhase = ExecutionPhase.AFTER_TEST_METHOD,
       config = @SqlConfig(errorMode = ErrorMode.FAIL_ON_ERROR,
                            commentPrefix = "//", separator = "@@") )
```

\*`DEFAULT` = whatever `@Sql` defines at class level, otherwise `FAIL_ON_ERROR`



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## Summary

- Testing is an *essential* part of any development
- Unit testing tests a class in isolation
  - External dependencies should be minimized
  - Consider creating stubs or mocks to unit test
  - *You don't need Spring to unit test*
- Integration testing tests the interaction of multiple units working together
  - Spring provides good integration testing support
  - Profiles for different test & deployment configurations
  - Built-in support for testing with Databases



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# Lab

## Testing Spring Applications

**Coming Up:** Appendix on Unit Testing using Stubs or Mocks



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## Topics in this Session

- Test Driven Development
- Integration Testing with Spring
- Testing with Profiles
- Testing with Databases
- **Appendix**
  - **Unit Testing (Stubs & Mocks)**



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## Unit Testing vs. Integration Testing

- Unit Testing
  - Tests one unit of functionality
  - Keeps dependencies minimal
  - Isolated from the environment (including Spring)
- Integration Testing
  - Tests the interaction of multiple units working together
  - Integrates infrastructure
- Discussed Integration Testing earlier
  - Let's discuss Unit Testing here
  - Remember: *Unit Testing does not use Spring*



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## Unit Testing

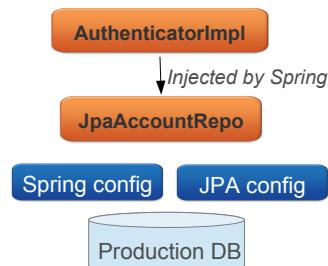
- Remove links with dependencies
  - The test shouldn't fail because of external dependencies
  - Spring is also considered as a dependency
  -
- 2 ways to create a “testing-purpose” implementation of your dependencies:
  - Stubs Create a simple test implementation
  - Mocks Dependency class generated at startup-time using a “Mocking framework”



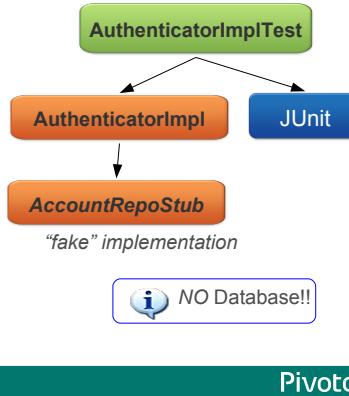
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## Unit Testing example

- Production mode



- Unit test with Stubs



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## Example Unit to be Tested

```
public class AuthenticatorImpl implements Authenticator {  
    private AccountRepository accountRepository;  
  
    public AuthenticatorImpl(AccountRepository accountRepository) {  
        this.accountRepository = accountRepository; External dependency  
    }  
  
    public boolean authenticate(String username, String password) {  
        Account account = accountRepository.getAccount(username);  
  
        return account.getPassword().equals(password);  
    }  
}  
  
Note: Validation failure paths ignored for simplicity
```

Unit business logic  
– 2 paths: success or fail

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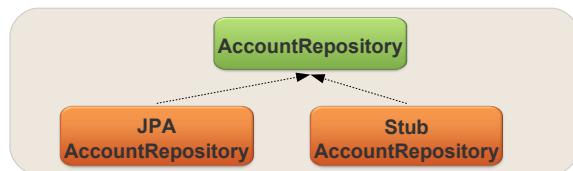
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## Implementing a Stub

- Class created manually
  - Implements Business interface

```
class StubAccountRepository implements AccountRepository {  
    public Account getAccount(String user) {  
        return "lisa".equals(user) ? new Account("lisa", "secret") : null;  
    }  
}
```

Simple state



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## Unit Test using a Stub

```
import org.junit.Before; import org.junit.Test; ...  
  
public class AuthenticatorImplTests {  
  
    private AuthenticatorImpl authenticator in charge of  
    @Before public void setUp() {  
        authenticator = new AuthenticatorImpl( new StubAccountRepository() );  
    }  
    @Test public void successfulAuthentication() {  
        assertTrue(authenticator.authenticate("lisa", "secret"));  
    }  
    @Test public void invalidPassword() {  
        assertFalse(authenticator.authenticate("lisa", "invalid"));  
    }  
}
```

injecting dependencies

OK scenario

KO scenario

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## Unit Testing with Stubs

- Advantages
  - Easy to implement and understand
  - Reusable
- Disadvantages
  - Change to an interface requires change to stub
  - Your stub must implement all methods
    - even those not used by a specific scenario
  - If a stub is reused refactoring can break other tests



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## Steps to Testing with a Mock

1. Use a mocking library to generate a mock object
  - Implements the dependent interface on-the-fly
2. Record the mock with expectations of how it will be used for a scenario
  - What methods will be called
  - What values to return
3. Exercise the scenario
4. Verify mock expectations were met



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## Example: Using a Mock - I

- Setup

- A Mock class is created at startup time

```
import static org.easymock.classextensions.EasyMock.*;
```

public class AuthenticatorImplTests {  
 private AccountRepository accountRepository  
 = createMock(AccountRepository.class);

private AuthenticatorImpl authenticator  
 = new AuthenticatorImpl(accountRepository);

// continued on next slide ...

## Example: Using a Mock - II

```
// ... continued from previous slide
```

```
@Test public void validUserWithCorrectPassword() {  

    expect(accountRepository.getAccount("lisa")).  

        andReturn(new Account("lisa", "secret"));
```

```
replay(accountRepository);
```

```
assertTrue(authenticator.  

    authenticate("lisa", "secret"));
```

```
verify(accountRepository);  

}
```

**Recording**

What behavior to expect?

Recording Playback

“playback” mode

Mock now fully available

Verification

No planned method call has been omitted

## Same Example using Mockito

```
import static org.mockito.Mockito.*;  
  
public class AuthenticatorImplTests {  
    private AccountRepository accountRepository  
        = mock(AccountRepository.class); // Create a mock object  
    private AuthenticatorImpl authenticator  
        = new AuthenticatorImpl(accountRepository); // Inject the mock object  
  
    @Test public void validUserWithCorrectPassword() {  
        when(accountRepository.getAccount("lisa")).thenReturn(new Account("lisa", "secret")); // Train the mock  
  
        assertTrue(authenticator.authenticate("lisa", "secret")); // Run test  
        verify(accountRepository).getAccount(); // Verify getAccount() was  
        // invoked on the mock  
    }  
}
```

No replay() step with Mockito



## Mock Considerations

- Several mocking libraries available
  - Mockito, JMock, EasyMock
- Advantages
  - No additional class to maintain
  - You only need to setup what is necessary for the scenario you are testing
  - Test behavior as well as state
    - Were all mocked methods used? If not, why not?
- Disadvantages
  - A little harder to understand at first



## Mocks or Stubs?

- You will probably use both
- General recommendations
  - Favor mocks for non-trivial interfaces
  - Use stubs when you have simple interfaces with repeated functionality
  - Always consider the specific situation
- Read “Mocks Aren’t Stubs” by Martin Fowler
  - <http://www.martinfowler.com/articles/mocksArentStubs.html>



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# Developing Aspects with Spring AOP

Aspect Oriented Programming For  
Declarative Enterprise Services

Using and Implementing Spring Proxies

## Topics in this session

- **What Problem Does AOP Solve?**
- Core AOP Concepts
- Quick Start
- Defining Pointcuts
- Implementing Advice
- Lab
- Advanced Topics



## What Problem Does AOP Solve?

- Aspect-Oriented Programming (AOP) enables modularization of cross-cutting concerns



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## What are Cross-Cutting Concerns?

- Generic functionality that is needed in many places in your application
- Examples
  - Logging and Tracing
  - Transaction Management
  - Security
  - Caching
  - Error Handling
  - Performance Monitoring
  - Custom Business Rules



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## An Example Requirement

- Perform a role-based security check before every application method



A sign this requirement is a cross-cutting concern



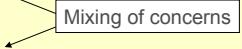
## Implementing Cross Cutting Concerns Without Modularization

- Failing to modularize cross-cutting concerns leads to two things
  - Code tangling
    - A coupling of concerns
  - Code scattering
    - The same concern spread across modules



## Symptom #1: Tangling

```
public class RewardNetworkImpl implements RewardNetwork {  
    public RewardConfirmation rewardAccountFor(Dining dining) {  
        if (!hasPermission(SecurityContext.getPrincipal())) {  
            throw new AccessDeniedException();  
        }  
  
        Account a = accountRepository.findByCreditCard(...);  
        Restaurant r = restaurantRepository.findByMerchantNumber(...);  
        MonetaryAmount amt = r.calculateBenefitFor(account, dining);  
        ...  
    }  
}
```

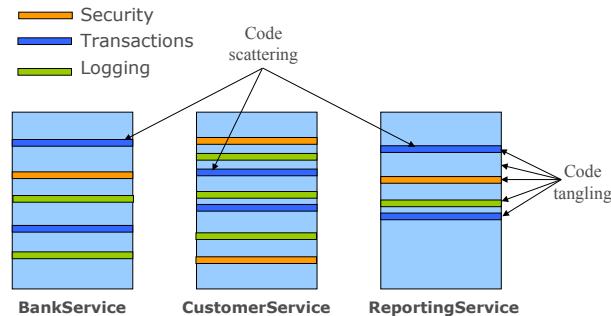


## Symptom #2: Scattering

```
public class JpaAccountManager implements AccountManager {  
    public Account getAccountForEditing(Long id) {  
        if (!hasPermission(SecurityContext.getPrincipal())) {  
            throw new AccessDeniedException();  
        }  
        ...  
    }  
}  
  
public class JpaMerchantReportingService  
    implements MerchantReportingService {  
    public List<DiningSummary> findDinings(String merchantNumber,  
                                              DateInterval interval) {  
        if (!hasPermission(SecurityContext.getPrincipal())) {  
            throw new AccessDeniedException();  
        }  
        ...  
    }  
}
```



## System Evolution Without Modularization



## Aspect Oriented Programming (AOP)

- Aspect-Oriented Programming (AOP) enables modularization of cross-cutting concerns
  - To avoid tangling
  - To eliminate scattering

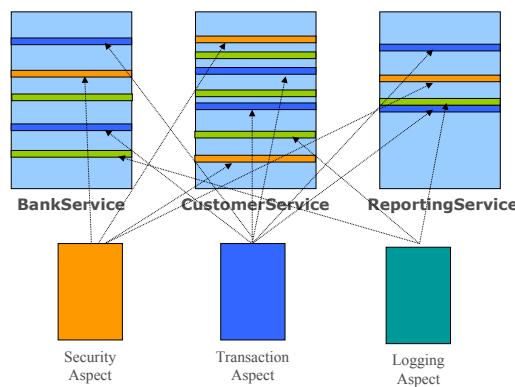


## How AOP Works

- Implement your mainline application logic
  - Focusing on the core problem
- Write aspects to implement your cross-cutting concerns
  - Spring provides many aspects out-of-the-box
- Weave the aspects into your application
  - Adding the cross-cutting behaviours to the right places



## System Evolution: AOP based



# Leading AOP Technologies

- AspectJ
  - Original AOP technology (first version in 1995)
  - A full-blown Aspect Oriented Programming language
    - Uses byte code modification for aspect weaving
- Spring AOP
  - Java-based AOP framework with AspectJ integration
    - Uses dynamic proxies for aspect weaving
  - Focuses on using AOP to solve enterprise problems
  - The focus of this session



See: **Spring Framework Reference – Aspect Oriented Programming**  
<http://docs.spring.io/spring/docs/current/spring-framework-reference/htmlsingle/#aop>



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## Topics in this session

- What Problem Does AOP Solve?
- **Core AOP Concepts**
- Quick Start
- Defining Pointcuts
- Implementing Advice
- Lab
- Advanced Topics



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## Core AOP Concepts

- Join Point
  - A point in the execution of a program such as a method call or exception thrown
- Pointcut
  - An expression that selects one or more Join Points
- Advice
  - Code to be executed at each selected Join Point
- Aspect
  - A module that encapsulates pointcuts and advice
- Weaving
  - Technique by which aspects are combined with main code



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## Topics in this session

- What Problem Does AOP Solve?
- Core AOP Concepts
- **Quick Start**
- Defining Pointcuts
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- Advanced Topics



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## AOP Quick Start

- Consider this basic requirement

*Log a message every time a property is about to change*

- How can you use AOP to meet it?



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## An Application Object Whose Properties Could Change

```
public class SimpleCache implements Cache
{
    private int cacheSize;
    private DataSource dataSource;
    private String name;

    public SimpleCache(String beanName) { name = beanName; }

    public void setCacheSize(int size) { cacheSize = size; }

    public void setDataSource(DataSource ds) { dataSource = ds; }

    ...

    public String toString() { return name; } // For convenience later
}
```

```
public interface Cache {
    public void setCacheSize(int size);
}
```



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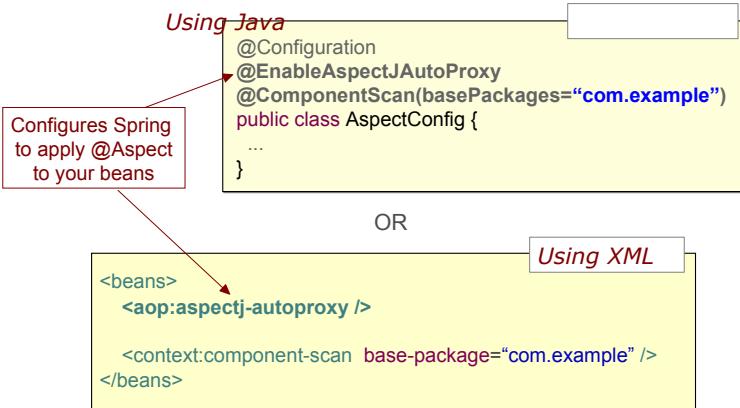
## Implement the Aspect

```
@Aspect  
@Component  
public class PropertyChangeTracker {  
    private Logger logger = Logger.getLogger(getClass());  
  
    @Before("execution(void set*(*))")  
    public void trackChange() {  
        logger.info("Property about to change...");  
    }  
}
```



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## Configure Aspect as a Bean



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## Include the Aspect Configuration

```
@Configuration  
@Import(AspectConfig.class)  
public class MainConfig {  
  
    @Bean  
    public Cache cacheA() { return new SimpleCache("cacheA"); }  
  
    @Bean  
    public Cache cacheB() { return new SimpleCache("cacheB"); }  
  
    @Bean  
    public Cache cacheC() { return new SimpleCache("cacheC"); }  
}
```

Include aspect configuration



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## Test the Application

```
ApplicationContext context = SpringApplication.run(MainConfig.class);
```

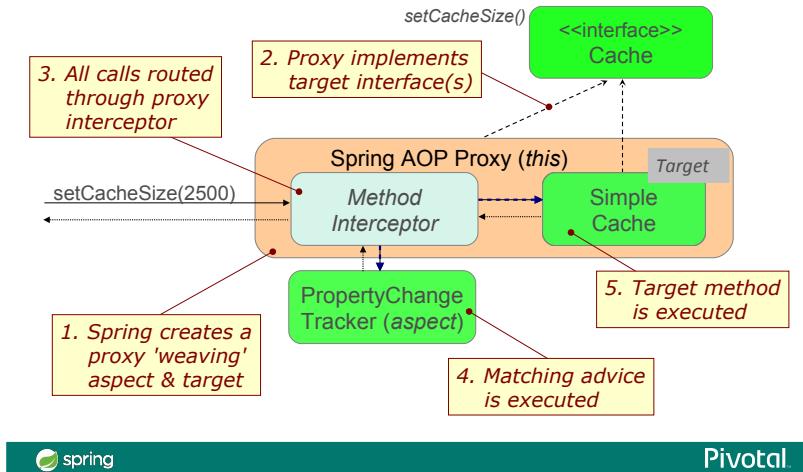
```
@Autowired @Qualifier("cacheA");  
private Cache cache;  
...  
cache.setCacheSize(2500);
```

INFO: Property about to change...



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## How Aspects are Applied



## Tracking Property Changes – With Context

- Context provided by the *JoinPoint* parameter

```
@Aspect  
public class PropertyChangeTracker {  
    private Logger logger = Logger.getLogger(getClass());  
  
    @Before("execution(void set*(*))")  
    public void trackChange(JoinPoint point) {  
        String name = point.getSignature().getName();  
        Object newValue = point.getArgs()[0];  
        logger.info(name + " about to change to " +  
                   newValue + " on " +  
                   point.getTarget());  
    }  
}
```

Annotations and context:

- Context about the intercepted point
- toString() returns bean-name
- INFO: setCacheSize about to change to 2500 on cacheA

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## Topics in this session

- What Problem Does AOP Solve?
- Core AOP Concepts
- Quick Start
- **Defining Pointcuts**
- Implementing Advice
- Lab
- Advanced Topics



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## Defining Pointcuts

- Spring AOP uses AspectJ's pointcut expression language
  - For selecting where to apply advice
- Complete expression language reference available at
  - <http://www.eclipse.org/aspectj/docs.php>
- Spring AOP supports a practical subset



See: **Spring Framework Reference – Declaring a Pointcut**

<http://docs.spring.io/spring/docs/current/spring-framework-reference/htmlsingle/#aop-pointcuts>



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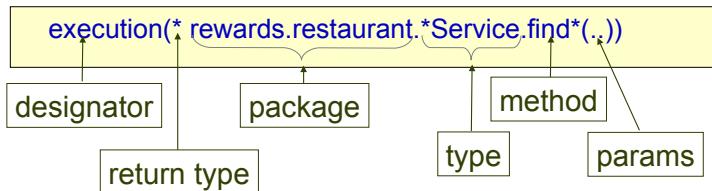
## Common Pointcut Designator

- execution(<method pattern>)
  - The method must match the pattern
- Can chain together to create composite pointcuts
  - && (and), || (or), ! (not)
- Method Pattern
  - [Modifiers] ReturnType [ClassType]  
    MethodName ([Arguments]) [throws ExceptionType]



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## Writing Expressions



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## Execution Expression Examples

### Any Class or Package

`execution(void send*(String))`

- Any method starting with send that takes a single String parameter and has a void return type

`execution(* send(*)`

- `Any method named send that takes a single parameter`

`execution(* send(int, ..))`

- `Any method named send whose first parameter is an int (the ".." signifies 0 or more parameters may follow)`



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## Execution Expression Examples

### Implementations vs Interfaces

- Restrict by *class*

`execution(void example.MessageServiceImpl.*(..))`

- `Any void method in the MessageServiceImpl class`
  - `Including any sub-class`

- But will be ignored if a different implementation is used

- Restrict by *interface*

`execution(void example.MessageService.send(*))`

- `Any void send method taking one argument, in any object implementing MessageService`

- More flexible choice – `works if implementation changes`



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## Execution Expression Examples

### Using Annotations

execution(@javax.annotation.security.RolesAllowed void send\*(..))

- Any void method whose name starts with "send" that is annotated with the @RolesAllowed annotation

```
public interface Mailer {  
    @RolesAllowed("USER")  
    public void sendMessage(String text);  
}
```

- Ideal for your own classes
  - Matches if annotation is present
  - Not if it isn't



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## Execution Expression Examples

### Working with Packages

execution(\* rewards.\*.restaurant.\*.\*(..))

- There is one directory between rewards and restaurant

execution(\* rewards..restaurant.\*.\*(..))

- There may be several directories between rewards and restaurant

execution(\* \*..restaurant.\*.\*(..))

- Any sub-package called restaurant



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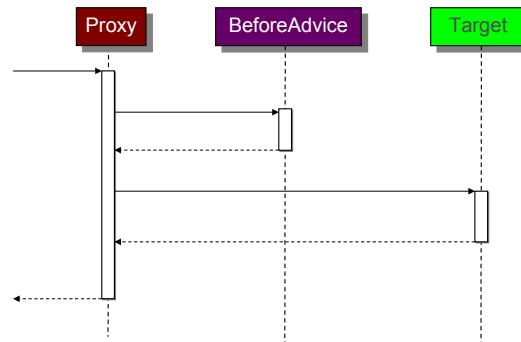
## Topics in this session

- What Problem Does AOP Solve?
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- Defining Pointcuts
- **Implementing Advice**
- Lab
- Advanced Topics



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## Advice Types: Before



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## Before Advice Example

- Use `@Before` annotation

```
@Aspect  
public class PropertyChangeTracker {  
    private Logger logger = Logger.getLogger(getClass());  
  
    @Before("execution(void set*(*))")  
    public void trackChange() {  
        logger.info("Property about to change...");  
    }  
}
```

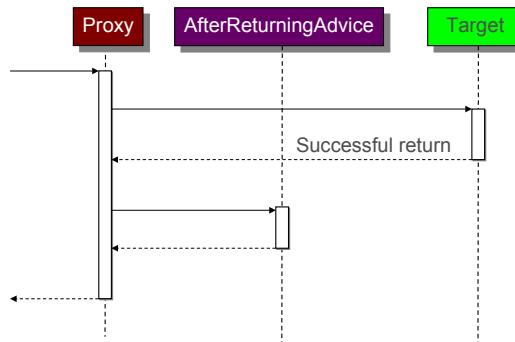
Track calls to all setter methods

- Note: if the advice throws an exception, target will not be called – this is a valid use of a *Before Advice*



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## Advice Types: After Returning



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## After Returning Advice - Example

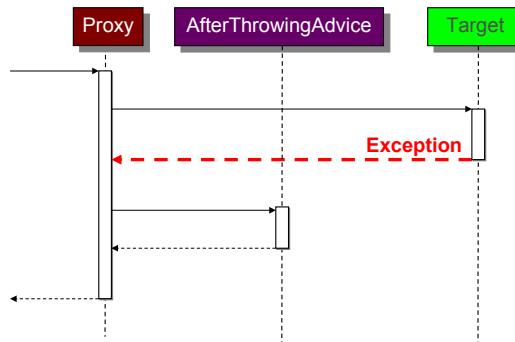
- Use `@AfterReturning` annotation with the *returning* attribute

Audit all operations in the *service* package that return a *Reward* object

```
@AfterReturning(value="execution(* service..*.*(..))",
               returning="reward")
public void audit(JoinPoint jp, Reward reward) {
    auditService.logEvent(jp.getSignature() +
        " returns the following reward object :" + reward.toString());
}
```



## Advice Types: After Throwing



## After Throwing Advice - Example

- Use `@AfterThrowing annotation` with the *throwing* attribute
  - Only invokes advice if the right exception type is thrown

Send an email every time a Repository class throws  
an exception of type DataAccessException

```
@AfterThrowing(value="execution(* *..Repository.*(..))", throwing="e")
public void report(JoinPoint jp, DataAccessException e) {
    mailService.emailFailure("Exception in repository", jp, e);
}
```



## After Throwing Advice - Propagation

- The `@AfterThrowing` advice will not stop the exception from propagating
  - However it can throw a different type of exception

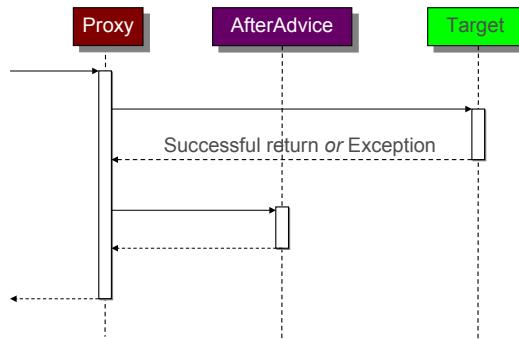
```
@AfterThrowing(value="execution(* *..Repository.*(..))", throwing="e")
public void report(JoinPoint jp, DataAccessException e) {
    mailService.emailFailure("Exception in repository", jp, e);
    throw new RewardsException(e);
}
```



If you wish to stop the exception from propagating any further, you can use an `@Around` advice (see later)



## Advice Types: After



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## After Advice Example

- Use `@After` annotation
  - Called regardless of whether an exception has been thrown by the target or not

```
@Aspect  
public class PropertyChangeTracker {  
    private Logger logger = Logger.getLogger(getClass());  
  
    @After("execution(void update(..))")  
    public void trackUpdate() {  
        logger.info("An update has been attempted ...");  
    }  
}
```

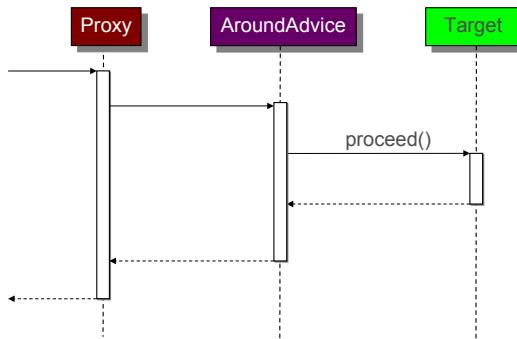
Track calls to all update methods

We don't know how the method terminated

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## Advice Types: Around



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## Around Advice Example

- Use `@Around` annotation and a `ProceedingJoinPoint`
  - Inherits from `JoinPoint` interface

```
@Around("execution(@example.Cacheable * rewards.service..*(..))")
public Object cache(ProceedingJoinPoint point) throws Throwable {
    Object value = cacheStore.get(CacheUtils.toKey(point));

    if (value == null) { ← Proceed only if not already cached
        value = point.proceed();
        cacheStore.put(CacheUtils.toKey(point), value);
    }

    return value;
} ← Cache values returned by cacheable services
```

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## Limitations of Spring AOP

- Can only advise *non-private* methods
- Can only apply aspects to *Spring Beans*
- Limitations of weaving with proxies
  - When using proxies, suppose method a() calls method b()  
on the *same* class/interface
    - advice will *never* be executed for method b()



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## Summary



- Aspect Oriented Programming (AOP) *modularizes cross-cutting concerns*
- An aspect is a module (Java class) containing the cross-cutting behavior
  - Annotated with `@Aspect`
  - Behavior is implemented as an “advice” method
  - Pointcuts select *joinpoints* (methods) where advice applies
  - Five advice types
    - Before, AfterThrowing, AfterReturning, After and Around



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# Lab

## Developing Aspects using Spring AOP

**Note:** The lab is working when

- 1) your unit test is **green** *and*
- 2) you get console logging output

**Coming Up:** Named pointcuts, context selection, annotations in pointcuts



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## Topics in this session

- What Problem Does AOP Solve?
- Core AOP Concepts
- Quick Start
- Defining Pointcuts
- Implementing Advice
- Advanced topics
  - XML Configuration
  - Named Pointcuts
  - Context-Selecting Pointcuts
  - Working with Annotations



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## Alternative Spring AOP Syntax - XML

- XML Based Alternative to @Annotations
  - More centralized configuration
- Approach
  - Aspect logic defined Java
  - Aspect configuration in XML
  - Uses the aop namespace



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## Tracking Property Changes - Java Code

```
public class PropertyChangeTracker {  
    public void trackChange(JoinPoint point) {  
        ...  
    }  
}
```

Aspect is a Plain Java Class with no annotations



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## Tracking Property Changes - XML Configuration

- XML configuration uses the `aop` namespace

```
<aop:config>
    <aop:aspect ref="propertyChangeTracker">
        <aop:before pointcut="execution(void set*(*))" method="trackChange"/>
    </aop:aspect>
</aop:config>

<bean id="propertyChangeTracker" class="example.PropertyChangeTracker" />
```



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## Topics in this session

- What Problem Does AOP Solve?
- Core AOP Concepts
- Quick Start
- Defining Pointcuts
- Implementing Advice
- Advanced topics
  - XML Configuration
  - **Named Pointcuts**
  - Context-Selecting Pointcuts
  - Working with Annotations



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## Named Pointcuts in XML

- A pointcut expression can have a name
  - Reuse it in multiple places

```
<aop:config>
    <aop:pointcut id="setterMethods" expression="execution(void set*(*))"/>

    <aop:aspect ref="propertyChangeTracker">
        <aop:after-returning pointcut-ref="setterMethods" method="trackChange"/>
        <aop:after-throwing pointcut-ref="setterMethods" method="logFailure"/>
    </aop:aspect>
</aop:config>

<bean id="propertyChangeTracker" class="example.PropertyChangeTracker" />
```



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## Named Pointcut Annotation

```
@Aspect
public class PropertyChangeTracker {
    private Logger logger = Logger.getLogger(getClass());

    @Before("serviceMethod() || repositoryMethod()")
    public void monitor() {
        logger.info("A business method has been accessed...");
    }

    @Pointcut("execution(* rewards.service..*Service.*(..))")
    public void serviceMethod() {}

    @Pointcut("execution(* rewards.repository..*Repository.*(..))")
    public void repositoryMethod() {}
}
```

The method *name* becomes the pointcut ID.  
The method is *not* executed.



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## Named Pointcuts

- Expressions can be externalized

```
public class Pointcuts {  
    @Pointcut("execution(* rewards.service..*Service.*(..))")  
    public void serviceMethods() {}  
}
```

```
@Aspect  
public class ServiceMethodInvocationMonitor {  
    private Logger logger = Logger.getLogger(getClass());  
  
    @Before( "com.acme.Pointcuts.serviceMethods()" )  
    public void monitor() {  
        logger.info("A service method has been accessed...");  
    }  
}
```

Fully-qualified pointcut name



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## Named Pointcuts - Summary

- Can break one complicated expression into several sub-expressions
- Allow pointcut expression reusability
- Best practice: consider externalizing expressions into one dedicated class
  - When working with many pointcuts
  - When writing complicated expressions



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## Topics in this session

- What Problem Does AOP Solve?
- Core AOP Concepts
- Quick Start
- Defining Pointcuts
- Implementing Advice
- Advanced topics
  - XML Configuration
  - Named Pointcuts
  - **Context Selecting Pointcuts**
  - Working with Annotations



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## Context Selecting Pointcuts

- Pointcuts may also select useful join point context
  - The target object
  - Method arguments
  - Annotations associated with the method, target, or arguments
  - The currently executing object (proxy)
- Allows for simple POJO advice methods
  - Alternative to working with a JoinPoint object directly



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## Context Selecting Example

- Consider this basic requirement

Log a message every time Server is about to start

```
public interface Server {  
    public void start(Map input);  
    public void stop();  
}
```

In the advice, how do we access Server? Map?



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## Without Context Selection

- All needed info must be obtained from *JoinPoint* object
  - No type-safety guarantees
  - Write advice *defensively*

```
@Before("execution(void example.Server.start(java.util.Map))")  
public void logServerStartup(JoinPoint jp) {  
    // A 'safe' implementation would also check target type  
    Server server = (Server) jp.getTarget();  
    // Don't assume args[0] exists  
    Object[] args= jp.getArgs();  
    Map map = args.length > 0 ? (Map) args[0] : new HashMap();  
    logger.info( server + " starting – params: " + map);  
}
```



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## With Context Selection

- Best practice: use context selection
  - Method attributes are bound automatically
  - Types must match or advice skipped

```
@Before("execution(void example.Server.start(java.util.Map))  
    && target(server) && args(input)")  
public void logServerStartup(Server server, Map input) {  
    ...  
}
```

- target(server) selects the target of the execution (your object)  
- this(server) would have selected the proxy



## Context Selection - Named Pointcut

```
@Before("serverStartMethod(server, input)")  
public void logServerStartup(Server server, Map input) {  
    ...  
} 'target' binds the server starting up 'args' binds the argument value  
  
@Pointcut("execution(void example.Server.start(java.util.Map))  
    && target(server) && args(input)")  
public void serverStartMethod (Server server, Map input) {}
```



## Topics in this session

- What Problem Does AOP Solve?
- Core AOP Concepts
- Quick Start
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  - **Working with Annotations**



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## Pointcut Expression Examples using Annotations

- Can match annotations everywhere
  - annotated methods, methods with annotated arguments, returning annotated objects, on annotated classes
- `execution(@org..transaction.annotation.Transactional * *(..))`
  - Any method marked with the `@Transactional` annotation
- `execution( (@example.Sensitive *) *(..))`
  - Any method that returns a type marked as `@Sensitive`

```
@Sensitive  
public class MedicalRecord { ... }  
  
public class MedicalService {  
    public MedicalRecord lookup(...) { ... }  
}
```



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## AOP and Annotations - Example

- Use of the *annotation()* designator

```
@Around("execution(* *(..)) && @annotation(txn)")  
public Object execute(ProceedingJoinPoint jp, Transactional txn) {  
    TransactionStatus tx;  
  
    try {  
        TransactionDefinition definition = new DefaultTransactionDefinition();  
        definition.setTimeout(txn.timeout());  
        definition.setReadOnly(txn.readOnly());  
        ...  
        tx = txnMgr.getTransaction(definition);  
        return jp.proceed();  
    }  
    ... // commit or rollback  
}
```

No need for `@Transactional` in `execution` expression – the `@annotation` matches it instead



## AOP and Annotations – Named pointcuts

- Same example using a named-pointcut

```
@Around("transactionalMethod(txn)")  
public Object execute(ProceedingJoinPoint jp, Transactional txn) {  
    ...  
  
    @Pointcut("execution(* *(..)) && @annotation(txn)")  
    public void transactionalMethod(Transactional txn) {}
```



## Advanced Topics Summary

- Topics covered were:
  - XML Configuration
  - Named Pointcuts
  - Context-Selecting Pointcuts
  - Working with Annotations



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# Introduction to Data Management with Spring

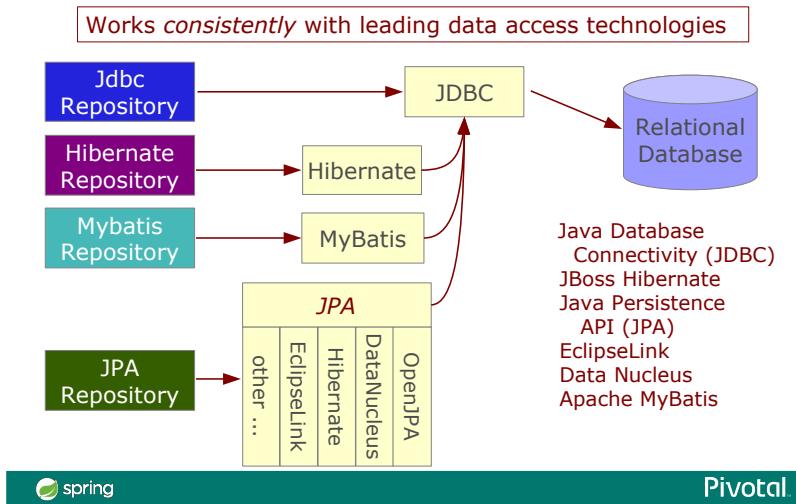
## Implementing Data Access and Caching

Spring's Role in Supporting Data Access in an Enterprise Application

## Topics in this Session

- **The Role of Spring in Enterprise Data Access**
- Spring's `DataAccessExceptionHierarchy`
- Using Test Databases
- Implementing Caching
- NoSQL databases

## Spring Resource Management Works Everywhere

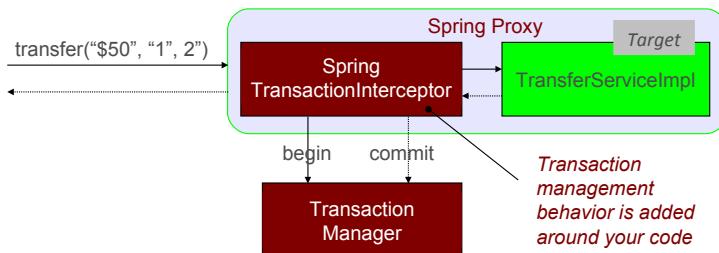


## The Resource Management Problem

- Steps Required
  - Access a data source and establish a connection
  - Begin a transaction
  - Do the work – execute business logic
  - Commit or rollback the transaction
  - Close the connection
- Spring Advantages
  - No code to implement (classic cross-cutting concern)
  - No connection or session leakage
  - Throws own exceptions, independent of underlying API

## Declarative Transaction Management

```
public class TransferServiceImpl implements TransferService {  
    @Transactional // marks method as needing a txn  
    public void transfer(...) { // your application logic  
    }
```



## Template Design Pattern

- Widely used and useful pattern
  - [http://en.wikipedia.org/wiki/Template\\_method\\_pattern](http://en.wikipedia.org/wiki/Template_method_pattern)
- Define the outline or skeleton of an algorithm
  - Leave the details to specific implementations later
  - Hides away large amounts of *boilerplate* code
- Spring provides many template classes
  - JdbcTemplate
  - JmsTemplate, RestTemplate, WebServiceTemplate ...
  - Most hide low-level resource management



## Where are my Transactions?

- Every thread needs its own transaction
  - Typically: a web-driven request
- Spring transaction management
  - Transaction manager handles transaction
    - Puts it into thread-local storage
  - Data-access code, like JdbcTemplate, finds it automatically
    - Or you can get it yourself:  
`DataSourceUtils.getConnection(dataSource)`



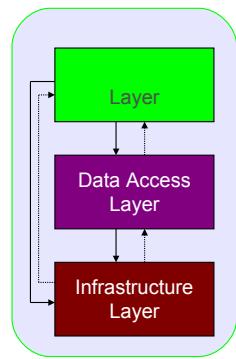
- Hibernate sessions, JTA (Java EE) work similarly

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## Data Access in a Layered Architecture

- Many enterprise applications consist of three logical layers
  - *Service Layer* (or application layer)
    - Exposes high-level application functions
    - Use-cases, business logic defined here
  - *Data access Layer*
    - Defines interface to the application's data repository (such as a Relational or NoSQL database)
  - *Infrastructure Layer*
    - Exposes low-level services to the other layers



*A classic Separation of Concerns*

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## Topics in this Session

- The Role of Spring in Enterprise Data Access
- **Spring's DataAccessExceptionHierarchy**
- Using Test Databases
- Implementing Caching
- NoSQL databases



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## Exception Handling

- Checked Exceptions
  - Force developers to handle errors
    - But if you can't handle it, must declare it
  - **Bad:** intermediate methods must declare exception(s) from *all* methods below
    - A form of tight-coupling
- Unchecked Exceptions
  - Can be thrown up the call hierarchy to the best place to handle it
  - **Good:** Methods in between don't know about it
    - Better in an Enterprise Application
  - Spring throws Runtime (unchecked) Exceptions



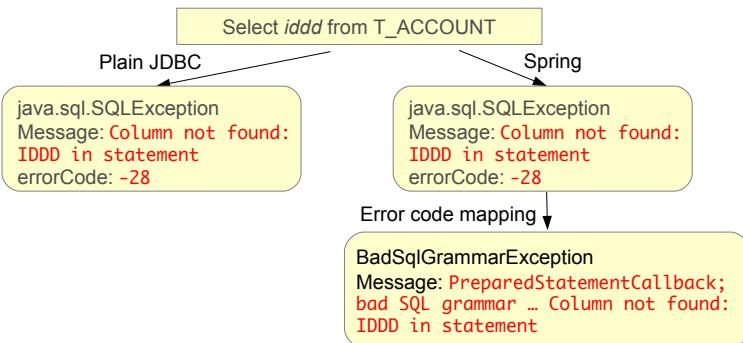
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# Data Access Exceptions

- SQLException
  - Too general – one exception for every database error
  - Calling class 'knows' you are using JDBC
  - Tight coupling
- Spring provides **DataAccessException** hierarchy
  - Hides whether you are using JPA, Hibernate, JDBC ...
  - Actually a hierarchy of sub-exceptions
    - Not just one exception for everything
  - Consistent across all supported Data Access technologies
  - Unchecked



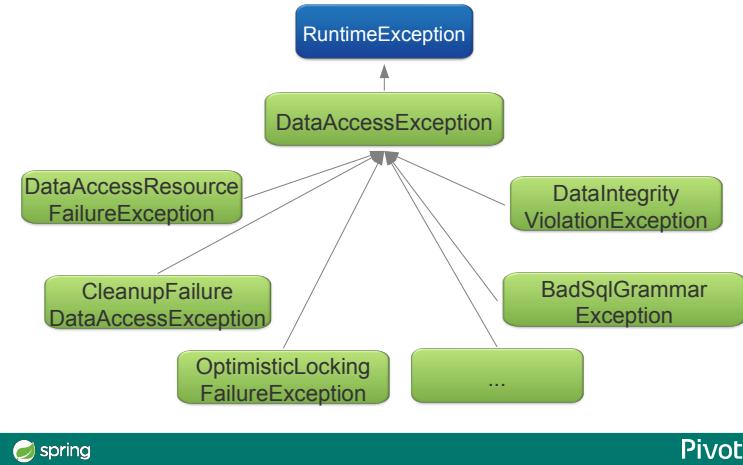
## Example: *BadSqlGrammarException*



For more details on error codes: see  
[spring-jdbc.jar/org/springframework/jdbc/support/sql-error-codes.xml](http://spring-jdbc.jar/org/springframework/jdbc/support/sql-error-codes.xml)



## Spring Data Access Exceptions



## Topics in this Session

- The Role of Spring in Enterprise Data Access
- Spring's `DataAccessExceptionHierarchy`
- **Using Test Databases**
- Implementing Caching
- NoSQL databases

## Embedded Database Builder

- Conveniently define a new (empty) in-memory database
  - And run script(s) to initialize it
  - HSQL, H2 and Derby are supported

```
@Bean  
public DataSource dataSource() {  
    EmbeddedDatabaseBuilder builder = new EmbeddedDatabaseBuilder();  
    return builder.setName("testdb")  
        .setType(EmbeddedDatabaseType.HSQL)  
        .addScript("classpath:/testdb/schema.db")  
        .addScript("classpath:/testdb/test-data.db").build();  
}
```



## JDBC Namespace Equivalent

- Especially useful for testing
  - Supports H2, HSQL and Derby

```
<bean class="example.order.JdbcOrderRepository" >  
    <property name="dataSource" ref="dataSource" />  
</bean>  
  
<jdbc:embedded-database id="dataSource" type="H2">  
    <jdbc:script location="classpath: schema.sql" />  
    <jdbc:script location="classpath: test-data.sql" />  
</jdbc:embedded-database>
```

In memory database  
(created at startup)



## Initializing an Existing Test Database

XML provides jdbc:initialize-database

- Namespace supports populating other DataSources, too

```
<bean id="dataSource" class="org.apache.commons.dbcp.BasicDataSource">
    <property name="url" value="${dataSource.url}" />
    <property name="username" value="${dataSource.username}" />
    <property name="password" value="${dataSource.password}" />
</bean>

<jdbc:initialize-database data-source="dataSource">
    <jdbc:script location="classpath:schema.sql" />
    <jdbc:script location="classpath:test-data.sql" />
</jdbc:initialize-database>
```

Initializes an **external** database



## Initializing and Existing Test Database

Java Configuration is not so Easy

```
@Configuration
public class DatabaseInitializer {
    @Value("classpath:schema.sql") private Resource schemaScript;
    @Value("classpath:test-data.sql") private Resource dataScript;

    private DatabasePopulator databasePopulator() {
        final ResourceDatabasePopulator populator =
            new ResourceDatabasePopulator();
        populator.addScript(schemaScript);
        populator.addScript(dataScript);
        return populator;
    }
}
```

Explicitly define a database Populator to run the init scripts

// continued on next slide



<http://stackoverflow.com/questions/16038360>



## Initializing and Existing Test Database

Java Configuration is not so Easy ... (continued)

- Bean can have any name, we won't use it (but Spring will)

```
// continued from previous slide
@Bean
public DataSourceInitializer anyName(final DataSource dataSource) {
    final DataSourceInitializer initializer = new DataSourceInitializer();
    initializer.setDataSource(dataSource);
    initializer.setDatabasePopulator(databasePopulator());
    return initializer;
}
```

Explicitly create a database  
initializer which will do the work  
in its post-construct method



<http://stackoverflow.com/questions/16038360>

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## Topics in this Session

- The Role of Spring in Enterprise Data Access
- Spring's `DataAccessExceptionHierarchy`
- Using Test Databases
- **Implementing Caching**
- NoSQL databases



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## About Caching

- What is a cache?
  - In this context: a key-value store = Map
- Where do we use this caching?
  - Any method that always returns the same result for the same argument(s)
    - This method could do anything
      - Calculate data on the fly
      - Execute a database query
      - Request data via RMI, JMS, a web-service ...
  - A unique key must be generated from the arguments
    - That's the cache key



## Caching Support

- Transparently applies caching to Spring beans (AOP)
  - Mark methods cacheable
    - Indicate caching key(s)
    - Name of cache to use (multiple caches supported)
  - Define one or more caches in Spring configuration



See: [Spring Framework Reference – Cache Abstraction](http://docs.spring.io/spring/docs/current/spring-framework-reference/htmlsingle/#cache)  
<http://docs.spring.io/spring/docs/current/spring-framework-reference/htmlsingle/#cache>



## Caching with @Cacheable

- `@Cacheable` marks a method for caching
  - its result is stored in a cache
  - subsequent invocations (with the *same arguments*)
    - fetch data from cache using key, method not executed
- `@Cacheable` attributes
  - value: name of cache to use
  - key: the key for each cached data-item
    - Uses SpEL and argument(s) of method

```
@Cacheable(value="topBooks", key="#refId.toUpperCase()")
public Book findBook(String refId) { ... }
```



## Caching via Annotations

```
public class BookService {
    @Cacheable(value="topBooks", key="#title", condition="#title.length < 32")
    public Book findBook(String title, boolean checkWarehouse) { ... }

    @Cacheable(value="topBooks", key="#author.name")
    public Book findBook2(Author author, boolean checkWarehouse) { ... }

    @Cacheable(value="topBooks", key="T(example.KeyGen).hash(#author)")
    public Book findBook3(Author author, boolean checkWarehouse) { ... }

    @CacheEvict(value="topBooks")
    public void loadBooks() { ... }
}
```

Annotations and their effects:

- `value="topBooks"`: Use 'topBooks' cache
- `key="#title"`: Only cache if condition true
- `key="#author.name"`: use object property
- `key="T(example.KeyGen).hash(#author)"`: custom key generator
- `value="topBooks"`: clear cache before method invoked



## Enabling Caching Proxy

- Caching must be enabled ...

```
@Configuration  
@EnableCaching  
public class MyConfig {  
    @Bean  
    public BookService bookService() { ... }  
}
```

OR

```
<cache:annotation-driven />  
  
<bean id="bookService" class="example.BookService" />
```



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## Pure XML Cache Setup

- Or use XML instead (for example with third-party class)

```
<bean id="bookService" class="example.BookService">  
<aop:config>  
    <aop:advisor advice-ref="bookCache"  
        pointcut="execution(* *.BookService.*(..))"/>  
    </aop:config>  
    <cache:advice id="bookCache" cache-manager="cacheManager">  
        <cache:caching cache="topBooks">  
            <cache:cacheable method="findBook" key="#refId"/>  
            <cache:cache-evict method="loadBooks" all-entries="true" />  
        </cache:caching>  
    </cache:advice>
```

XML Cache Setup – no @Cachable



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## Setup Cache Manager

- Must specify a cache-manager
  - Some provided, or write your own
  - See `org.springframework.cache` package
- SimpleCacheManager
  - For each cache name, it creates a `ConcurrentHashMap`

```
@Bean  
public CacheManager cacheManager() {  
    SimpleCacheManager cacheManager =  
        new SimpleCacheManager("topAuthors", "topBooks");  
    return cacheManager;  
}  
} Concurrent Map Cache
```

Keep `cacheManager` bean name

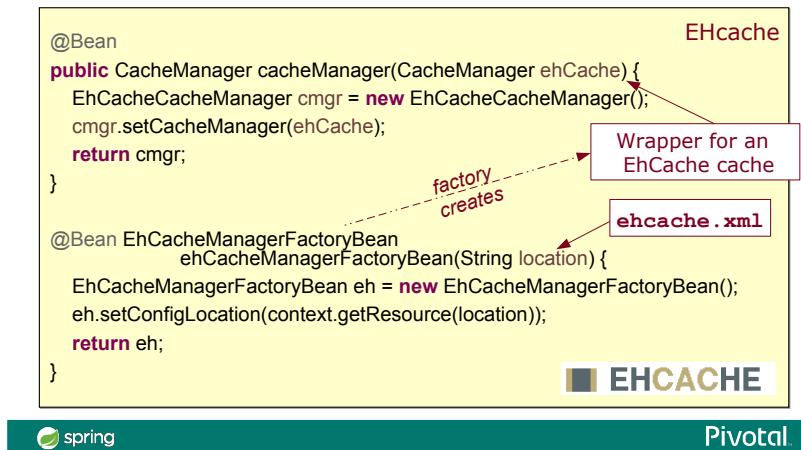


## Third-Party Cache Implementations

- Simple Cache is OK for testing
  - But has no cache control options (overflow, eviction)
- Third-party alternatives
  - Terracotta's EhCache
  - Google's Guava and Caffeine
  - Pivotal's Gemfire



## Third-Party Cache Manager – EHCache



## Third-Party Cache Managers – Gemfire

- Gemfire: A distributed, shared nothing data-grid
  - Can be used to setup a distributed cache
  - Caches (regions) replicated across multiple nodes
    - Consistent updates occur on all copies in parallel
    - No loss of data if a storage node fails
    - Automatic recovery and rebalancing



```
<gfe:cache-manager p:cache-ref="gemfire-cache"/>  
<gfe:cache id="gemfire-cache"/>  
  
<gfe:replicated-region id="topAuthors" p:cache-ref="gemfire-cache"/>  
<gfe:partitioned-region id="topBooks" p:cache-ref="gemfire-cache"/>
```



# Spring Gemfire Project



- GemFire configuration in Spring config files
  - Also enables configuration injection for environments
- Features
  - Exception translation
  - GemfireTemplate
  - Transaction management (*GemfireTransactionManager*)
  - Injection of transient dependencies during deserialization
  - *Gemfire Cache Manager class*

**GEMFIRE**<sup>®</sup>



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## Topics in this Session

- The Role of Spring in Enterprise Data Access
- Spring's `DataAccessExceptionHierarchy`
- Using Test Databases
- Implementing Caching
- **NoSQL databases**



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## Not Only Relational



SPRING DATA

- NoSQL
  - Relational databases only store some data
    - LDAP, data-warehouses, files
    - Most documents and spreadsheets aren't in *any* database
- Other database products exist
  - Have strengths where RDB are weak
    - Non-tabular data
      - Hierarchical data: parts inventory, org chart
      - Network structures: telephone cables, roads, molecules
      - Documents: XML, spreadsheets, contracts, ...
      - Geographical data: maps, GPS navigation
      - Many more ...



## So Many Choices ...

- Many options – each has a particular strength

- Document databases

- MongoDB, *CouchDB coming*



- Distributed key-value Stores (smart caches)

- Redis, Riak



- Network (graph) database

- Neo4j



- Big Data

- Apache Hadoop (VMware Serengeti)



- Data Grid

- Gemfire



- Column Stores coming: HBase, Cassandra



## Summary

- Data Access with Spring
  - Enables layered architecture principles
    - Higher layers should not know about data management below
  - Isolate via Data Access Exceptions
    - Hierarchy makes them easier to handle
  - Provides consistent transaction management
  - Supports most leading data-access technologies
    - Relational and non-relational (NoSQL)
  - A key component of the core Spring libraries
  - Automatic caching facility



# Introduction to Spring JDBC

## Using JdbcTemplate

Simplifying JDBC-based data-access with Spring

## Topics in this Session

- **Problems with traditional JDBC**
  - Results in redundant, error prone code
  - Leads to poor exception handling
- **Spring's JdbcTemplate**
  - Configuration
  - Query execution
  - Working with result sets
  - Exception handling



See: **Spring Framework Reference – Data access with JDBC**  
<http://docs.spring.io/spring/docs/current/spring-framework-reference/htmlsingle/#jdbc>

## Redundant, Error Prone Code

```
public List findByLastName(String lastName) {  
    List personList = new ArrayList();  
    Connection conn = null;  
    String sql = "select first_name, age from PERSON where last_name=?";  
    try {  
        DataSource dataSource = DataSourceUtils.getDataSource();  
        conn = dataSource.getConnection();  
        PreparedStatement ps = conn.prepareStatement(sql);  
        ps.setString(1, lastName);  
        ResultSet rs = ps.executeQuery();  
        while (rs.next()) {  
            personList.add(new Person(rs.getString("first_name"), ...));  
        }  
    } catch (SQLException e) { /* ??? */ }  
    finally {  
        try {  
            conn.close();  
        } catch (SQLException e) { /* ??? */ }  
    }  
    return personList;  
}
```



## Redundant, Error Prone Code

```
public List findByLastName(String lastName) {  
    List personList = new ArrayList();  
    Connection conn = null;  
    String sql = "select first_name, age from PERSON where last_name=?";  
    try {  
        DataSource dataSource = DataSourceUtils.getDataSource();  
        conn = dataSource.getConnection();  
        PreparedStatement ps = conn.prepareStatement(sql);  
        ps.setString(1, lastName);  
        ResultSet rs = ps.executeQuery();  
        while (rs.next()) {  
            personList.add(new Person(rs.getString("first_name"), ...));  
        }  
    } catch (SQLException e) { /* ??? */ }  
    finally {  
        try {  
            conn.close();  
        } catch (SQLException e) { /* ??? */ }  
    }  
    return personList;  
}
```

The bold matters - the  
rest is boilerplate



## Poor Exception Handling

```
public List findByName(String lastName) {  
    List personList = new ArrayList();  
    Connection conn = null;  
    String sql = "select first_name, age from PERSON where last_name=?";  
    try {  
        DataSource dataSource = DataSourceUtils.getDataSource();  
        conn = dataSource.getConnection();  
        PreparedStatement ps = conn.prepareStatement(sql);  
        ps.setString(1, lastName);  
        ResultSet rs = ps.executeQuery();  
        while (rs.next()) {  
            personList.add(new Person(rs.getString("first_name"), ...));  
        }  
    } catch (SQLException e) { /* ??? */ }  
    finally {  
        try {  
            conn.close();  
        } catch (SQLException e) { /* ??? */ }  
    }  
    return personList;  
}
```

What can  
you do?



## Topics in this session

- Problems with traditional JDBC
  - Results in redundant, error prone code
  - Leads to poor exception handling
- **Spring's JdbcTemplate**
  - Configuration
  - Query execution
  - Working with result sets
  - Exception handling



## Spring's JdbcTemplate

- Greatly simplifies use of the JDBC API
  - Eliminates repetitive boilerplate code
  - Alleviates common causes of bugs
  - Handles SQLExceptions properly
- Without sacrificing power
  - Provides full access to the standard JDBC constructs



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## JdbcTemplate in a Nutshell

```
int count = jdbcTemplate.queryForObject(  
    "SELECT COUNT(*) FROM CUSTOMER", Integer.class);
```

- Acquisition of the connection
- Participation in the transaction
- Execution of the statement
- Processing of the result set
- Handling any exceptions
- Release of the connection

All handled  
by Spring



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## JdbcTemplate Approach Overview

```
List<Customer> results = jdbcTemplate.query(someSql,  
    new RowMapper<Customer>() {  
        public Customer mapRow(ResultSet rs, int row) throws SQLException {  
            // map the current row to a Customer object  
        }  
    });  
  
class JdbcTemplate {  
    public List<Customer> query(String sql, RowMapper rowMapper) {  
        try {  
            // acquire connection  
            // prepare statement  
            // execute statement  
            // for each row in the result set  
            results.add(rowMapper.mapRow(rs, rowNum));  
        } catch (SQLException e) {  
            // convert to root cause exception  
        } finally {  
            // release connection  
        }  
    }  
}
```



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## Creating a JdbcTemplate

- Requires a DataSource

```
JdbcTemplate template = new JdbcTemplate(dataSource);
```

- Create a template once and re-use it
  - Do not create one for each thread
  - Thread safe after construction



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## When to use JdbcTemplate

- Useful standalone
  - Anytime JDBC is needed
  - In utility or test code
  - To clean up messy legacy code
- Useful for implementing a repository in a layered application
  - Also known as a data access object (DAO)



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## Implementing a JDBC-based Repository

```
public class JdbcCustomerRepository implements CustomerRepository {  
    private JdbcTemplate jdbcTemplate;  
  
    public JdbcCustomerRepository(DataSource dataSource) {  
        this.jdbcTemplate = new JdbcTemplate(dataSource);  
    }  
  
    public int getCustomerCount() {  
        String sql = "select count(*) from customer";  
        return jdbcTemplate.queryForObject(sql, Integer.class);  
    }  
}
```

No try / catch needed  
(unchecked exception)



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## Querying with JdbcTemplate

- JdbcTemplate can query for
  - Simple types (int, long, String, Date, ...)
  - Generic Maps
  - Domain Objects



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## Query for Simple Java Types

- Query with no bind variables: *queryForObject*

```
public Date getOldest() {  
    String sql = "select min(dob) from PERSON";  
    return jdbcTemplate.queryForObject(sql, Date.class);  
}  
  
public long getPersonCount() {  
    String sql = "select count(*) from PERSON";  
    return jdbcTemplate.queryForObject(sql, Long.class);  
}
```



*queryForInt, queryForLong deprecated since Spring 3.2, just as easy to queryForObject instead (API improved in Spring 3)*



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## Query With Bind Variables

- Can query using bind variables: ?
  - Note the use of a variable argument list

```
private JdbcTemplate jdbcTemplate;

public int getCountOfNationalsOver(Nationality nationality, int age) {
    String sql = "select count(*) from PERSON " +
        "where age > ? and nationality = ?";
    return jdbcTemplate.queryForObject
        (sql, Integer.class, age, nationality.toString());
}
```

Bind to first ? Bind to second ?



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## Generic Queries

- *JdbcTemplate* returns each row of a *ResultSet* as a **Map**
- When expecting a single row
  - Use `queryForMap(..)`
- When expecting multiple rows
  - Use `queryForList(..)`
- Useful for *ad hoc* reporting, testing use cases
  - The data fetched does not need mapping to a Java object



*ad hoc* – created or done for a particular purpose as necessary  
– sometimes called “window-on-data” queries



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## Querying for Generic Maps (1)

- Query for a single row

```
public Map<String, Object> getPersonInfo(int id) {  
    String sql = "select * from PERSON where id=?";  
    return jdbcTemplate.queryForMap(sql, id);  
}
```

- returns:

```
Map { ID=1, FIRST_NAME="John", LAST_NAME="Doe" }
```

A Map of [Column Name | Field Value] pairs



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## Querying for Generic Maps (2)

- Query for multiple rows

```
public List<Map<String, Object>> getAllPersonInfo() {  
    String sql = "select * from PERSON";  
    return jdbcTemplate.queryForList(sql);  
}
```

- returns:

```
List {  
    0 - Map { ID=1, FIRST_NAME="John", LAST_NAME="Doe" }  
    1 - Map { ID=2, FIRST_NAME="Jane", LAST_NAME="Doe" }  
    2 - Map { ID=3, FIRST_NAME="Junior", LAST_NAME="Doe" }  
}
```

A List of Maps of [Column Name | Field Value] pairs



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## Domain Object Queries

- Often it is useful to map relational data into domain objects
  - e.g. a ResultSet to an Account
- Spring's JdbcTemplate supports this using a callback approach
- You may prefer to use ORM for this
  - Need to decide between JdbcTemplate queries and JPA (or similar) mappings
  - Some tables may be too hard to map with JPA



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## RowMapper

- Spring provides a RowMapper interface for mapping a single row of a ResultSet to an object
  - Can be used for both single and multiple row queries
  - Parameterized as of Spring 3.0

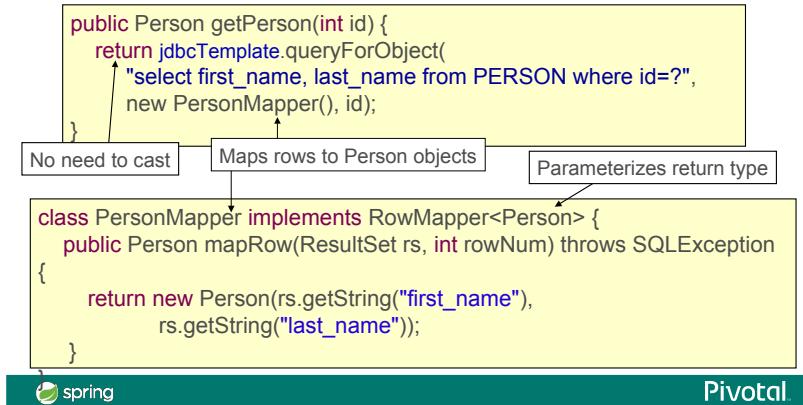
```
public interface RowMapper<T> {  
    T mapRow(ResultSet rs, int rowNum)  
        throws SQLException;  
}
```



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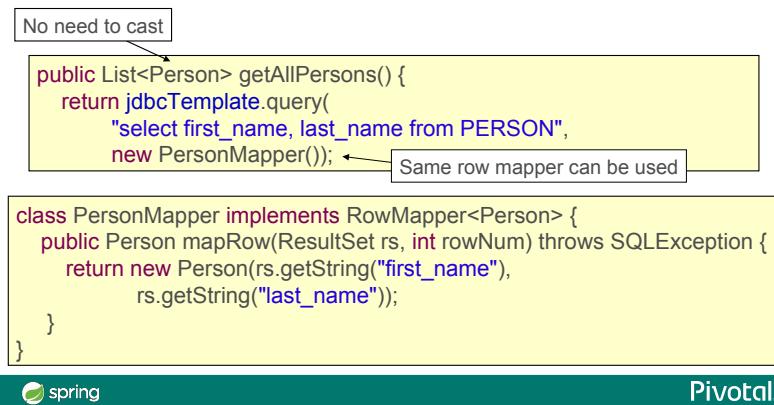
## Querying for Domain Objects (1)

- Query for single row with JdbcTemplate



## Querying for Domain Objects (2)

- Query for multiple rows



## Querying for Domain Objects (3)

- Simplify using Java 8 Lambda Expressions
  - No need for Mapper class
  - Use inline code instead

```
public List<Person> getAllPersons() {  
    return jdbcTemplate.query(  
        "select first_name, last_name from PERSON",  
        (rs, rowNum) -> {  
            return new Person(rs.getString("first_name"),  
                rs.getString("last_name"));  
        });  
}  
  
public interface RowMapper<T> {  
    public T mapRow(ResultSet rs, int rowNum) throws SQLException;  
}
```

Replace RowMapper by a lambda



## RowCallbackHandler

- Spring provides a simpler RowCallbackHandler interface when there is no return object
  - Streaming rows to a file
  - Converting rows to XML
  - Filtering rows before adding to a Collection
    - *but filtering in SQL is much more efficient*
  - Faster than JPA equivalent for big queries
    - avoids result-set to object mapping

```
public interface RowCallbackHandler {  
    void processRow(ResultSet rs) throws SQLException;  
}
```



## Using a RowCallbackHandler (1)

```
public class JdbcOrderRepository {  
    public void generateReport(Writer out) {  
        // select all orders of year 2009 for a full report  
        jdbcTemplate.query("select * from order where year=?",  
                          new OrderReportWriter(out), 2009);  
    }  
}
```

returns "void"

```
class OrderReportWriter implements RowCallbackHandler {  
    public void processRow(ResultSet rs) throws SQLException {  
        // parse current row from ResultSet and stream to output  
    }  
    // May also be a stateful object: you could accumulate data and add  
    // convenience methods like getTotalOrderValue(), getCount() ...  
}
```



## Using a RowCallbackHandler (2)

- Might use a Lambda – if *no* state needed
  - Need to cast, tells Java which callback lambda replaces

```
public class JdbcOrderRepository {  
    public void generateReport(final PrintWriter out) {  
        // select all orders of year 2009 for a full report  
        jdbcTemplate.query("select * from order where year=?",  
                          (RowCallbackHandler)(rs) ->  
                          { out.write(rs.getString("customer") ... );  
                            2016});  
    }  
}
```

Cast needed

Or using a *lambda*

```
public interface RowCallbackHandler {  
    void processRow(ResultSet rs) throws SQLException;  
}
```



## ResultSetExtractor

- Spring provides a ResultSetExtractor interface for processing an entire ResultSet at once
  - You are responsible for iterating the ResultSet
  - e.g. for mapping entire ResultSet to a single object

```
public interface ResultSetExtractor<T> {  
    T extractData(ResultSet rs) throws SQLException,  
        DataAccessException;  
}
```



You may need this for the lab!



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## Using a ResultSetExtractor (1)

```
public class JdbcOrderRepository {  
    public Order findByConfirmationNumber(String number) {  
        // execute an outer join between order and item tables  
        return jdbcTemplate.query(  
            "select...from order o, item i...conf_id = ?",  
            new OrderExtractor(), number);  
    }  
}  
  
class OrderExtractor implements ResultSetExtractor<Order> {  
    public Order extractData(ResultSet rs) throws SQLException {  
        Order order = null;  
        while (rs.next()) {  
            if (order == null) {  
                order = new Order(rs.getLong("ID"), rs.getString("NAME"), ...);  
            }  
            order.addItem(mapItem(rs));  
        }  
        return order;  
    }  
}
```



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## Using a ResultSetExtractor (2)

```
public class JdbcOrderRepository {  
    public Order findByConfirmationNumber(String number) {  
        // execute an outer join between order and item tables  
        return jdbcTemplate.query(  
            "select...from order o, item i...conf_id = ?",  
            (ResultSetExtractor<Order>)(rs) -> {  
                Order order = null;  
                while (rs.next()) {  
                    if (order == null)  
                        order = new Order(rs.getLong("ID"), rs.getString("NAME"), ...);  
  
                    order.addItem(mapItem(rs));  
                }  
                return order;  
            },  
            number);  
    }  
}
```

Or using a *lambda*

```
public interface ResultSetExtractor<T> {  
    T extractData(ResultSet rs)  
    throws SQLException, DataAccessException;  
}
```



## Summary of Callback Interfaces

- RowMapper
  - Best choice when *each* row of a ResultSet maps to a domain object
- RowCallbackHandler
  - Best choice when *no value* should be returned from the callback method for *each* row, especially large queries
- ResultSetExtractor
  - Best choice when *multiple* rows of a ResultSet map to a *single* object



## Inserts and Updates (1)

- Inserting a new row
  - Returns number of rows modified

```
public int insertPerson(Person person) {  
    return jdbcTemplate.update(  
        "insert into PERSON (first_name, last_name, age)" +  
        "values (?, ?, ?)",  
        person.getFirstName(),  
        person.getLastName(),  
        person.getAge());  
}
```



## Inserts and Updates (2)

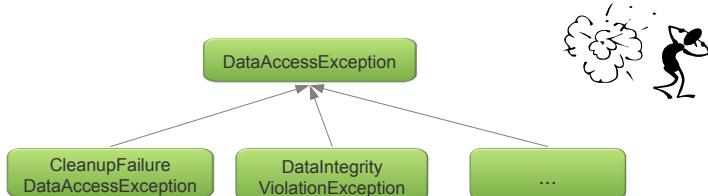
- Updating an existing row

```
public int updateAge(Person person) {  
    return jdbcTemplate.update(  
        "update PERSON set age=? where id=?",  
        person.getAge(),  
        person.getId());  
}
```



## Exception Handling

- The JdbcTemplate transforms SQLExceptions into DataAccessExceptions



*DataAccessException* hierarchy was discussed in module “Introduction to Data Access”. You can refer to it for more information on this topic.



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## Summary

- JDBC is useful
  - But using JDBC API directly is tedious and error-prone
- JdbcTemplate* simplifies data access and enforces consistency
  - DRY principle hides most of the JDBC
  - Many options for reading data
- SQLExceptions* typically cannot be handled where thrown
  - Should not be *checked Exceptions*
  - Spring provides *DataAccessException* instead



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# Lab

Reimplementing repositories using  
Spring's JdbcTemplate



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# Transaction Management with Spring

Spring's Consistent Approach

Transactional Proxies and @Transactional

## Topics in this session

- **Why use Transactions?**
- Java Transaction Management
- Spring Transaction Management
- Isolation Levels
- Transaction Propagation
- Rollback rules
- Testing
- Advanced topics

## What is a Transaction?

- A set of tasks which take place as a single, indivisible action
  - An *Atomic, Consistent, Isolated, Durable* operation
  - Acronym: **ACID**



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## Why use Transactions? To Enforce the ACID Principles

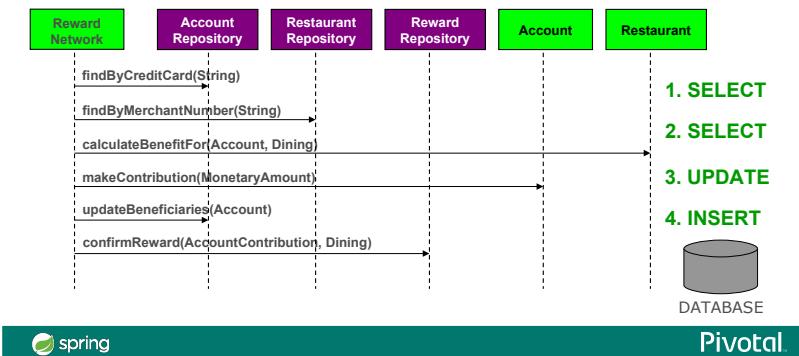
- **A**tomic
  - Each unit of work is an all-or-nothing operation
- **C**onsistent
  - Database integrity constraints are never violated
- **I**solated
  - Isolating transactions from each other
- **D**urable
  - Committed changes are permanent

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## Transactions in the RewardNetwork

- The *rewardAccountFor(Dining)* method represents a unit-of-work that should be atomic



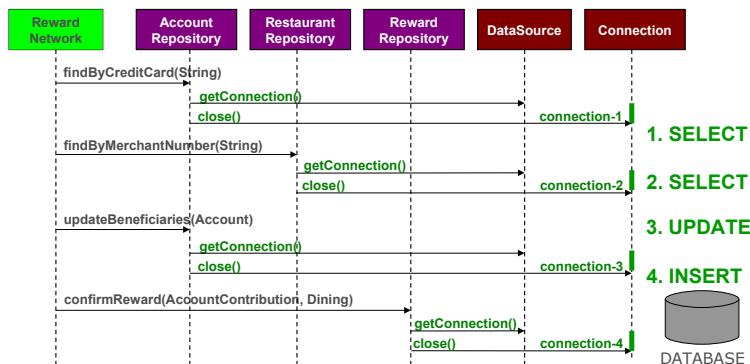
## Naïve Approach

Connection per Data Access Operation

- This unit-of-work contains 4 data access operations
  - Each acquires, uses, and releases a distinct Connection
- The unit-of-work is ***non-transactional***



## Running non-Transactionally

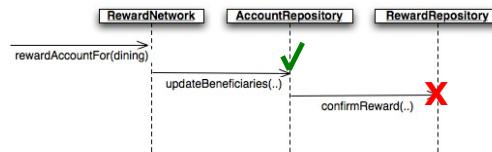


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## Partial Failures

- Suppose an Account is being rewarded



- If the beneficiaries are updated...
- But the reward confirmation fails...
- There will be no record of the reward!

The unit-of-work  
is **not atomic**

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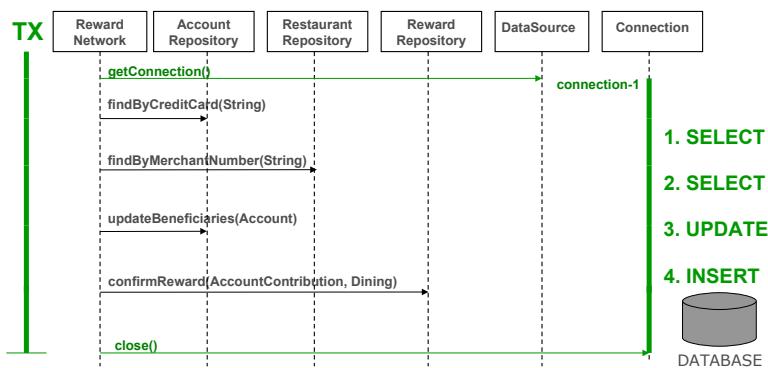
## Correct Approach

### Connection per Unit-of-Work

- More efficient
  - Same Connection reused for each operation
- Operations complete as an atomic unit
  - Either all succeed or all fail
- The unit-of-work can run in a *transaction*



## Running in a Transaction



## Topics in this session

- Why use Transactions?
- **Java Transaction Management**
- Spring Transaction Management
- Isolation Levels
- Transaction Propagation
- Rollback rules
- Testing
- Advanced topics



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## Java Transaction Management

- Java has several APIs which handle transactions differently
  - JDBC, JMS, JTA, Hibernate, JPA, etc.
- Each uses program code to mark the start and end of the transaction
  - Transaction Demarcation
- Different APIs for Global vs Local transactions



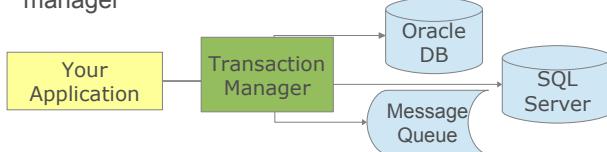
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# Local and Global Transaction Management

- Local Transactions – Single Resource
  - Transactions managed by underlying resource



- Global (distributed) Transactions – Multiple
  - Transaction managed by separate, dedicated transaction manager



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## JDBC Transaction Management Example

```
try {
    conn = dataSource.getConnection();
    conn.setAutoCommit(false);
    ...
    conn.commit();
} catch (Exception e) {
    conn.rollback();
}
}
```

Specific To JDBC API

Programmatic Transaction Demarcation

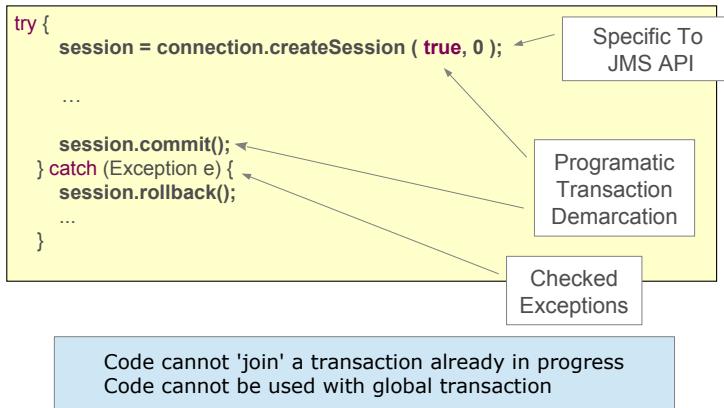
Checked Exceptions

Code cannot 'join' a transaction already in progress  
Code cannot be used with global transaction

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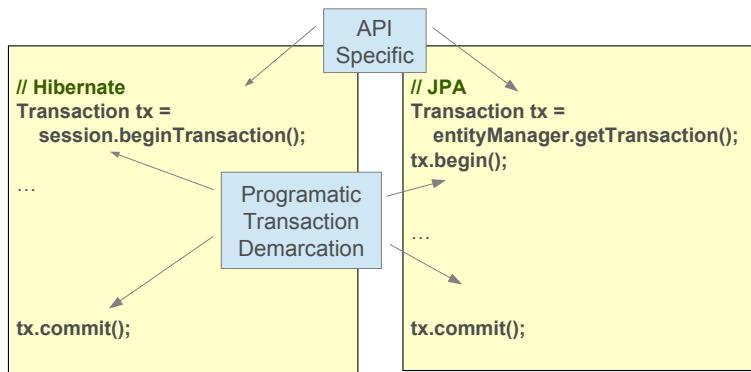
## JMS Transaction Management Example



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## JPA / Hibernate Transaction Management Example



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## Java Transaction API (JTA) Example

```
try {  
    UserTransaction ut =  
        (UserTransaction) new InitialContext()  
            .lookup("java:comp/UserTransaction");  
    ut.begin(); ←  
    ...  
  
    ut.commit(); ←  
} catch (Exception e) {  
    ut.rollback(); ←  
    ...  
}
```

Programmatic  
Transaction  
Demarcation

Checked  
Exceptions

Requires a JTA implementation:

- "Full" application server (WebSphere, WebLogic, JBoss, etc.)
- Standalone implementation (Atomikos, JTOM, etc.)



## Problems with Java Transaction Management



- Multiple APIs for different local resources
- Programmatic transaction demarcation
  - Typically performed in the repository layer (wrong place)
  - Usually repeated (cross-cutting concern)
- Service layer more appropriate
  - Multiple data access methods often called within a single transaction
  - But: don't want data-access code in service-layer
- Orthogonal concerns
  - Transaction demarcation should be independent of transaction implementation



## Topics in this session

- Why use Transactions?
- Java Transaction Management
- **Spring Transaction Management**
- Isolation Levels
- Transaction Propagation
- Rollback rules
- Testing
- Advanced topics



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## Spring Transaction Management – 1

- Spring separates transaction *demarcation* from transaction *implementation*
  - Demarcation expressed declaratively via AOP
    - Programmatic approach also available
  - **PlatformTransactionManager** abstraction hides implementation details.
    - Several implementations available
- Spring uses the same API for global vs. local.
  - Change from local to global is minor
    - Just change the transaction manager



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## Spring Transaction Management – 2

- There are only 2 steps
  - Declare a **PlatformTransactionManager** bean
  - Declare the transactional methods
    - Using Annotations, XML, Programmatic
    - Can mix and match



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## PlatformTransactionManager

- Spring's **PlatformTransactionManager** is the base interface for the abstraction
- Several implementations are available
  - DataSourceTransactionManager
  - HibernateTransactionManager
  - JpaTransactionManager
  - JtaTransactionManager
  - WebLogicJtaTransactionManager
  - WebSphereUowTransactionManager
  - *and more*



Spring allows you to configure whether you use JTA or not.  
It does not have *any* impact on your Java classes



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## Deploying the Transaction Manager

- Create the required implementation
  - Just like any other Spring bean
    - Configure as appropriate
  - Here is the manager for a DataSource

A DataSource  
bean must be  
defined elsewhere

```
@Bean  
public PlatformTransactionManager  
transactionManager(DataSource dataSource) {  
    return new DataSourceTransactionManager(dataSource);  
}
```



Bean id “*transactionManager*” is default name. Can change it, but must specify alternative name everywhere – easier not to!



## @Transactional Configuration

In your code

```
nts PlatformRewardNetworkImpl  
@Transactional  
public RewardConfirmation rewardAccountFor(Dining d) {  
    // atomic unit-of-work  
}
```

In your Spring configuration

```
@Configuration  
@EnableTransactionManagement  
public class TxnConfig {  
    @Bean  
    public PlatformTransactionManager transactionManager(DataSource ds) {  
        return new DataSourceTransactionManager(ds);  
    }  
}
```

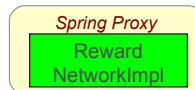
Defines a Bean Post-Processor  
– proxies @Transactional beans

Or use <tx:annotation-driven/> - see Advanced Section

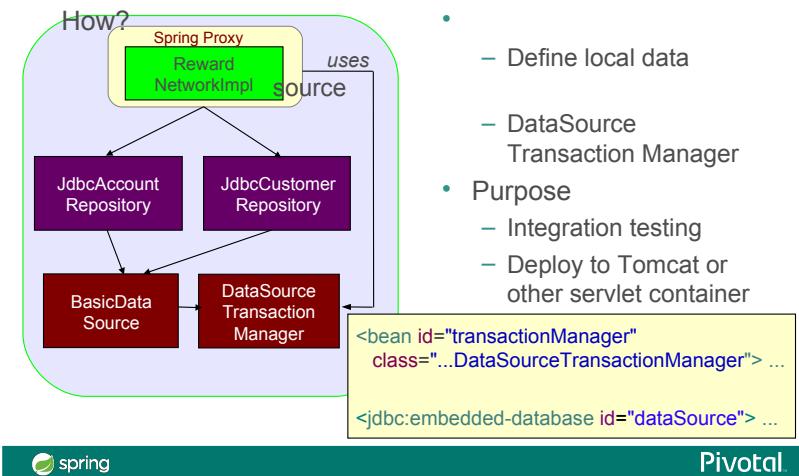


## @Transactional: What Happens Exactly?

- Target object wrapped in a proxy
  - Uses an Around advice
- Proxy implements the following behavior
  - Transaction started before entering the method
  - Commit at the end of the method
  - Rollback if method throws a RuntimeException
    - Default behavior
    - Can be overridden (see later)
- Transaction context bound to current thread.
- All controlled by *configuration*

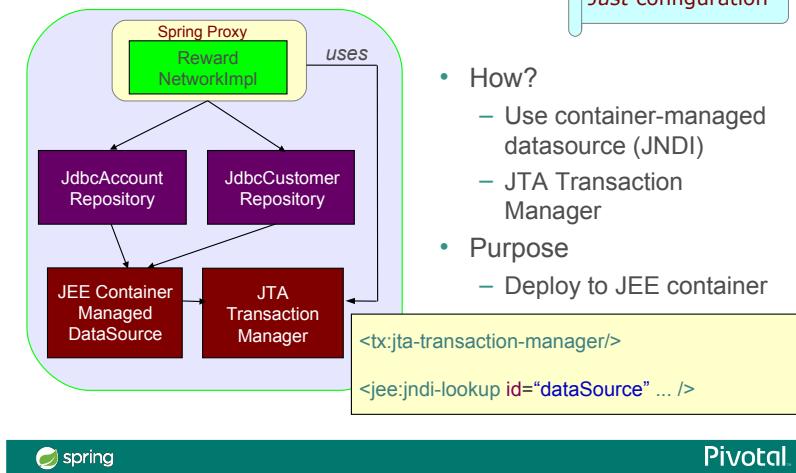


## Local JDBC Configuration



# JDBC Java EE Configuration

No code changes  
Just configuration



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## @Transactional – Class Level

- Applies to all methods declared by the interface(s)

```
@Transactional
public class RewardNetworkImpl implements RewardNetwork {

    public RewardConfirmation rewardAccountFor(Dining d) {
        // atomic unit-of-work
    }

    public RewardConfirmation updateConfirmation(RewardConfirmation rc) {
        // atomic unit-of-work
    }
}
```



Alternatively `@Transactional` can be declared on the interface instead  
– if not using Spring Boot nor CGLIB proxies

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## @Transactional

### – Class *and* method levels

- Combining class and method levels

```
@Transactional(timeout=60) ← default settings
public class RewardNetworkImpl implements RewardNetwork {

    public RewardConfirmation rewardAccountFor(Dining d) {
        // atomic unit-of-work
    }
    @Transactional(timeout=45) ← override attributes at method level
    public RewardConfirmation updateConfirmation(RewardConfirmation rc) {
        // atomic unit-of-work
    }
}
```



## Topics in this session

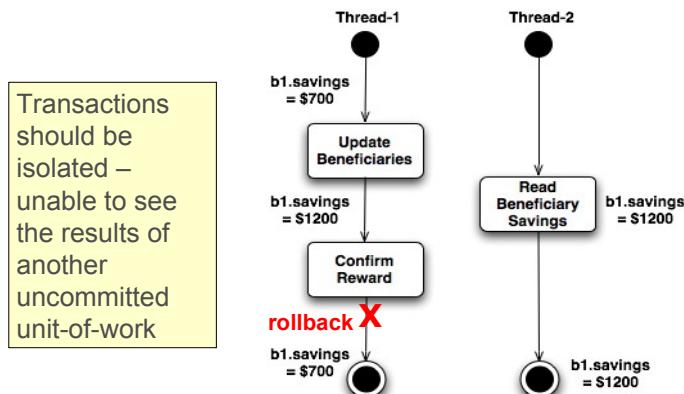
- Why use Transactions?
- Java Transaction Management
- Spring Transaction Management
- Isolation Levels**
- Transaction Propagation
- Rollback rules
- Testing
- Advanced topics



## Isolation levels

- 4 isolation levels can be used:
  - READ\_UNCOMMITTED
  - READ\_COMMITTED
  - REPEATABLE\_READ
  - SERIALIZABLE
- Some DBMSs do not support all isolation levels
- Isolation is a complicated subject
  - DBMS all have differences in the way their isolation policies have been implemented
  - We just provide general guidelines

## Dirty Reads



## READ\_UNCOMMITTED

- Lowest isolation level – allows *dirty reads*
- Current transaction can see the results of another uncommitted unit-of-work
- Typically used for large, intrusive read-only transactions
- And/or where the data is constantly changing

```
public class RewardNetworkImpl implements RewardNetwork {  
    @Transactional (isolation=Isolation.READ_UNCOMMITTED)  
    public BigDecimal totalRewards(String merchantNumber, int year)  
        // Calculate total rewards for a restaurant for a whole year  
    }  
}
```



## READ\_COMMITTED

- Does not allow dirty reads
  - Only committed information can be accessed
- Default strategy for most databases

```
public class RewardNetworkImpl implements RewardNetwork {  
    @Transactional (isolation=Isolation.READ_COMMITTED)  
    public RewardConfirmation rewardAccountFor(Dining dining)  
        // atomic unit-of-work  
    }  
}
```



## Highest isolation levels

- REPEATABLE\_READ
  - Does not allow dirty reads
  - Non-repeatable reads are prevented
    - If a row is read twice in the same transaction, result will always be the same
      - Might result in locking depending on the DBMS
- SERIALIZABLE
  - Prevents non-repeatable reads and dirty-reads
  - Also prevents phantom reads



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## Topics in this session

- Why use Transactions?
- Java Transaction Management
- Spring Transaction Management
- Isolation Levels
- **Transaction Propagation**
- Rollback rules
- Testing
- Advanced topics



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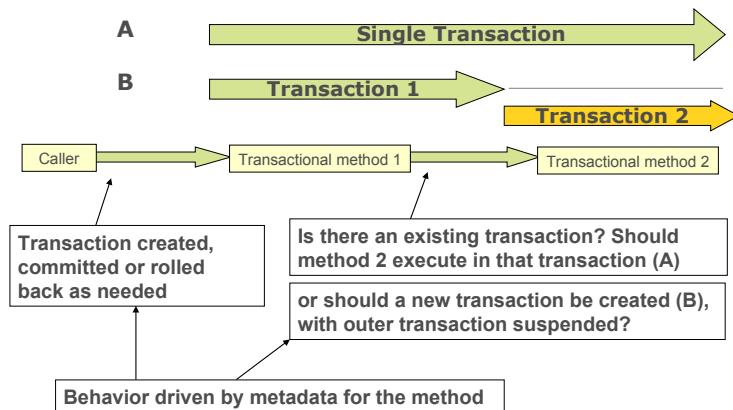
## Understanding Transaction Propagation

- Consider the sample below. What should happen if ClientServiceImpl calls AccountServiceImpl?
  - Should everything run into a single transaction?
  - Should each service have its own transaction?

```
public class ClientServiceImpl  
    implements ClientService {  
    @Autowired  
    private AccountService accountService;  
  
    @Transactional  
    public void updateClient(Client c)  
    { // ...  
        this.accountService.update(c.getAccounts());  
    }  
}  
  
public class AccountServiceImpl  
    implements AccountService {  
    @Transactional  
    public void update(List <Account> l)  
    { // ...  
    }  
}
```

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## Understanding Transaction Propagation



# Transaction Propagation with Spring

- 7 levels of propagation
- The following examples show *REQUIRED* and *REQUIRES\_NEW*
  - Check the documentation for other levels
- Can be used as follows:

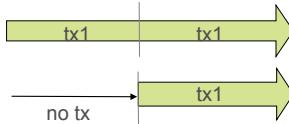
```
@Transactional(propagation=Propagation.REQUIRES_NEW)
```



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## REQUIRED

- REQUIRED
  - Default value
  - Execute within a current transaction, create a new one if none exists



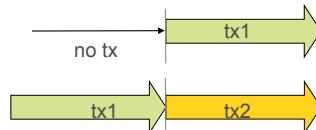
```
@Transactional(propagation=Propagation.REQUIRED)
```



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## REQUIRES\_NEW

- REQUIRES\_NEW
  - Create a new transaction, suspending the current transaction if one exists



`@Transactional(propagation=Propagation.REQUIRES_NEW)`



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## Topics in this session

- Why use Transactions?
- Java Transaction Management
- Spring Transaction Management
- Isolation Levels
- Transaction Propagation
- **Rollback rules**
- Testing
- Advanced topics



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## Default Behavior

- By default, a transaction is rolled back if a RuntimeException has been thrown
  - Could be any kind of RuntimeException:  
DataAccessException, HibernateException etc.

```
public class RewardNetworkImpl implements RewardNetwork {  
    @Transactional  
    public RewardConfirmation rewardAccountFor(Dining d) {  
        // ...  
        throw new RuntimeException();  
    }  
}
```

Triggers a rollback



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## rollbackFor and noRollbackFor

- Default settings can be overridden with *rollbackFor* and/or *noRollbackFor* attributes

```
public class RewardNetworkImpl implements RewardNetwork {  
    @Transactional(rollbackFor=MyCheckedException.class,  
                 noRollbackFor={JmxException.class, MailException.class})  
    public RewardConfirmation rewardAccountFor(Dining d) throws Exception {  
        // ...  
    }  
}
```



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## Topics in this session

- Why use Transactions?
- Java Transaction Management
- Spring Transaction Management
- Isolation Levels
- Transaction Propagation
- Rollback rules
- **Testing**
- Advanced topics



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## @Transactional within Integration Test

- Annotate test method (or class) with **@Transactional**
  - Runs test methods in a transaction
  - Transaction will be *rolled back* afterwards
    - No need to clean up your database after testing!

```
@ContextConfiguration(classes=RewardsConfig.class)
@RunWith(SpringJUnit4ClassRunner.class)
public class RewardNetworkTest {
    @Test @Transactional
    public void testRewardAccountFor() {
        ...
    }
}
```

This test is now  
transactional



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## Controlling Transactional Tests

```
@ContextConfiguration(classes=RewardsConfig.class)
@RunWith(SpringJUnit4ClassRunner.class)
@Transactional
public class RewardNetworkTest {

    @Test
    @Commit
    public void testRewardAccountFor() {
        ... // Whatever happens here will be committed
    }
}
```

Make *all* tests  
transactional

Commit transaction  
at end of test



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## Lab

Managing Transactions Declaratively  
using Spring Annotations

**Coming Up:** Programmatic transactions, read-only and multiple  
transactions, Global transactions, Propagation options



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## Topics in this session

- Advanced topics
  - (1) XML Configuration
  - (2) Programmatic transactions
  - (3) Read-only transactions
  - (4) More on Transactional Tests
  - (5) Multiple and Global Transactions
  - (6) Propagation Options



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## 1. Deploying the Transaction Manager

- Declare as a Spring Bean

```
<bean id="transactionManager"
      class="org.springframework.jdbc.datasource.DataSourceTransactionManager">
    <property name="dataSource" ref="dataSource"/>
</bean>
```

A dataSource  
must be defined  
elsewhere



Bean id “*transactionManager*” is default name. Can change it but must specify alternative name everywhere – easier not to!



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## Automatic JTA Implementation Resolution

- For JTA, also possible to use custom XML tag:

```
<tx:jta-transaction-manager/>
```

- Resolves to appropriate implementation for the environment
  - WebLogicJtaTransactionManager
  - WebSphereUowTransactionManager
  - JtaTransactionManager
  - OC4JJtaTransactionManager
    - Obsolete, removed after Spring 3.2



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## @Transactional Configuration Using XML

- Annotate classes and methods with `@Transactional` in usual way
- Enable using tx namespace in the configuration:

```
<tx:annotation-driven/>           Defines a Bean Post-Processor  
                                         - proxies @Transactional beans  
  
<bean id="transactionManager"  
      class="org.springframework.jdbc.datasource.DataSourceTransactionManager">  
    <property name="dataSource" ref="dataSource"/>  
</bean>  
  
<jdbc:embedded-database id="dataSource"> ... </jdbc:embedded-database>
```



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# 100% XML-based Spring Transactions

- @Transactional not always an option
  - Someone else may have written the service (without annotations)
  - Legacy code written before @Transactional
- Spring provides support for 100% XML
  - Predates annotations
  - An AOP pointcut declares what to advise
  - Spring's `tx` namespace enables a concise definition of transactional advice
  - Can add transactional behavior to any class used as a Spring Bean



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## Declarative Transactions: XML

```
<aspect name="rewardNetworkMethods">
    <!-- aspect named pointcut expression -->
    <aop:config>
        <aop:pointcut id="rewardNetworkMethods"
            expression="execution(* rewards.RewardNetwork.*(..))"/>
        <aop:advisor pointcut-ref="rewardNetworkMethods" advice-ref="txAdvice"/>
    </aop:config>
    <tx:advice id="txAdvice">
        <tx:attributes>
            <tx:method name="get*" read-only="true" timeout="10"/>
            <tx:method name="find*" read-only="true" timeout="10"/>
            <tx:method name="*" timeout="30"/>
        </tx:attributes>
    </tx:advice>
    <bean id="transactionManager"
        class="org.springframework.jdbc.datasource.DataSourceTransactionManager">
        <property name="dataSource" ref="dataSource"/>
    </bean>
```

Method-level configuration for transactional advice

Includes rewardAccountFor(..) and updateConfirmation(..)



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## 2. Programmatic Transactions with Spring

- Declarative transaction management is highly recommended
  - Clean code
  - Flexible configuration
- Spring does enable programmatic transaction
  - Works with local or JTA transaction manager
  - `TransactionTemplate` plus callback



Can be useful inside a technical framework that would not rely on external configuration



### Programmatic Transactions: example

```
Method not  
public RewardConfirmation rewardAccountFor(Dining dining) {  
    ...  
    return new TransactionTemplate(txManager).execute( (status) -> {  
        try {  
            ...  
            accountRepository.updateBeneficiaries(account);  
            confirmation = rewardRepository.confirmReward(contribution, dining);  
        }  
        catch (RewardException e) {  
            status.setRollbackOnly();  
            confirmation = new RewardFailure();  
        }  
        return confirmation;  
    };  
}
```

`@Transactional`

`Lambda syntax`

`Method no longer throws exception, using status to perform manual rollback`

`public interface TransactionCallback<T> {  
 public T doInTransaction(TransactionStatus status)  
 throws Exception;  
}`



### 3. Read-only Transactions – Faster

- Why use transactions if you're only planning to read data?
  - Performance: allows Spring to optimize the transactional resource for read-only data access

```
public void rewardAccount1() {  
    jdbcTemplate.queryForList(...);  
    jdbcTemplate.queryForInt(...);  
}  
  
@Transactional(readOnly=true)  
public void rewardAccount2() {  
    jdbcTemplate.queryForList(...);  
    jdbcTemplate.queryForInt(...);  
}
```

2 connections

1 single connection



### Read-only Transactions – Isolation

- Why use transactions if you're only planning to read data?
  - With a high isolation level, a read-only transaction prevents data from being modified until the transaction commits

```
@Transactional(readOnly=true, isolation=Isolation.REPEATABLE_READ)  
public void importantAccounts() {  
    List accounts = jdbcTemplate.queryForList  
        ("SELECT * FROM Accounts WHERE balance > 1000000");  
    process(accounts);  
    int nAccounts = jdbcTemplate.queryForInt  
        ("SELECT count(*) FROM Accounts WHERE balance > 1000000");  
    assert accounts.size() == nAccounts;  
}
```



## 4. Transactional Tests

### @Before vs @BeforeTransaction

```
@ContextConfiguration(locations={"/rewards-config.xml"})
@RunWith(SpringJUnit4ClassRunner.class)
public class RewardNetworkTest {
    @BeforeTransaction
    public void verifyInitialDatabaseState() {...}
    @Before
    public void setUpTestDataInTransaction() {...}
    @Test @Transactional
    public void testRewardAccountFor() { ... }
```

Run before transaction is started

Within the transaction



@After and @AfterTransaction work in the same way as @Before and @BeforeTransaction

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## @Sql and Transaction Control

- Transaction control options
  - *ISOLATED*: Used with *txn*, a PTM *must* exist
  - *INFERRRED*: If PTM exists, txn started using default propagation (so it uses txn around test method) otherwise a DataSource *must* exist (used with *no txn*)
  - *DEFAULT*: Whatever @Sql defines at class level, INFERRRED otherwise

```
@Sql( scripts = "/test-user-data.sql",
       config = @SqlConfig(
           transactionMode = TransactionMode.ISOLATED,
           transactionManager = "myTxnMgr",
           dataSource= "myDataSource" )
```

Optionally specify bean ids

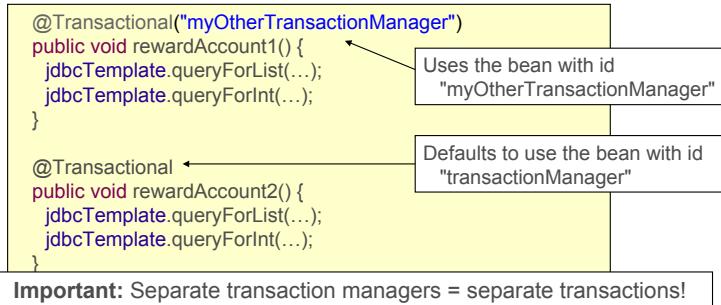
*PTM = PlatformTransactionManager, txn = transaction*

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## 5. Multiple Transaction Managers

- `@Transactional` can declare the id of the transaction manager that should be used

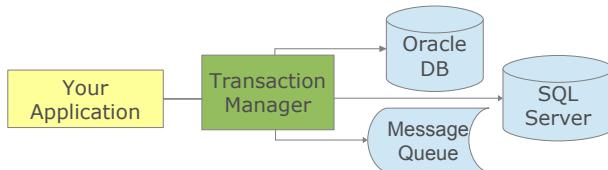


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## Global Transactions

- Also called distributed transactions
- Involve multiple dissimilar resources:



- Global transactions typically require JTA and specific drivers (XA drivers)
  - Two-phase commit protocol

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## Global Transactions → Spring Integration

- Many possible strategies
  - Spring allows you to switch easily from a non-JTA to a JTA transaction policy
  - Just change the type of the transaction manager
- Reference:
  - *Distributed transactions with Spring, with and without XA*  
by Dr. Dave Syer

<http://www.javaworld.com/javaworld/jw-01-2009/jw-01-spring-transactions.html>

**Learn More: Enterprise Spring**

– 4 day course, including *global transactions*



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## 6. Propagation Levels and their Behaviors

Propagation Type	If NO current transaction	If there is a current transaction
<b>MANDATORY</b>	throw exception	use current transaction
<b>NEVER</b>	don't create a transaction, run method outside any transaction	throw exception
<b>NOT_SUPPORTED</b>	don't create a transaction, run method outside any transaction	suspend current transaction, run method outside any transaction
<b>SUPPORTS</b>	don't create a transaction, run method outside any transaction	use current transaction
<b>REQUIRED(default)</b>	create a new transaction	use current transaction
<b>REQUIRES_NEW</b>	create a new transaction	suspend current transaction, create a new independent transaction
<b>NESTED</b>	create a new transaction	create a new nested transaction



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# JPA with Spring and Spring Data

Object Relational Mapping with  
Spring & Java Persistence API

Using JPA with Spring, Spring Data Repositories

## Topics in this session

- **Introduction to JPA**
  - General Concepts
  - Mapping
  - Querying
- Configuring JPA in Spring
- Implementing JPA DAOs
- Spring Data – JPA
- Lab
- Optional and Advanced Topics

## Introduction to JPA

- The Java Persistence API is designed for operating on domain objects
  - Defined as POJO entities
  - No special interface required
- Replaces previous persistence mechanisms
  - EJB Entity Beans
  - Java Data Objects (JDO)
- A common API for object-relational mapping
  - Derived from the experience of existing products such as JBoss Hibernate and Oracle TopLink



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## About JPA

- Java Persistence API
  - Current version: 2.1 May 2013
  - 2.2 Under discussion
- Configuration
  - Persistence Unit
- Key Features
  - Entity Manager
  - Entity Manager Factory
  - Persistence Context



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## JPA Configuration

- **Persistence Unit**

- Describes a group of persistent classes (entities)
- Defines provider(s)
- Defines transactional types (local vs JTA)
- Multiple Units per application are allowed
- Defined by the file: `persistence.xml`



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## JPA General Concepts

- **EntityManager**

- Manages a unit of work and persistent objects therein: the `PersistenceContext`
- Lifecycle often bound to a Transaction (usually container-managed)

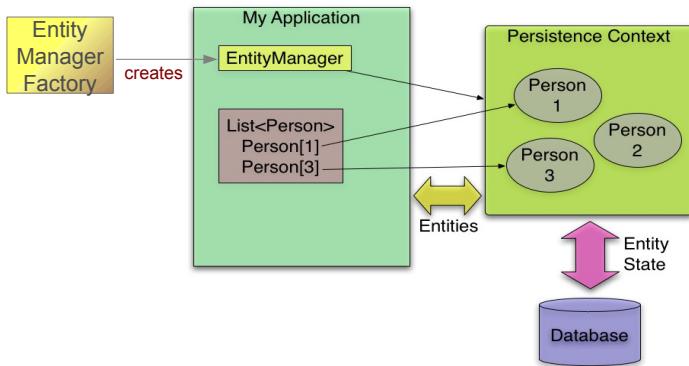
- **EntityManagerFactory**

- thread-safe, shareable object that represents a single data source / persistence unit
- Provides access to new application-managed EntityManagers

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## Persistence Context and EntityManager



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## The EntityManager API

the entity <code>entity</code> to Persistence	Context: <i>SQL: insert into table ...</i>
<code>remove(Object o)</code>	Removes the entity from the Persistence Context: <i>SQL: delete from table ...</i>
<code>find(Class entity, Object primaryKey)</code>	Find by primary key: <i>SQL: select * from table where id = ?</i>
<code>Query createQuery(String jpqlString)</code>	Create a JPQL query
<code>flush()</code>	Force changed entity state to be written to database immediately

Plus other methods ...

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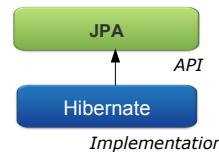
## JPA Providers

- Several major implementations of JPA spec
  - Hibernate EntityManager
    - Used inside Jboss
  - EclipseLink (RI)
    - Used inside Glassfish
  - Apache OpenJPA
    - Used by Oracle WebLogic and IBM Websphere
  - Data Nucleus
    - Used by Google App Engine
- **Can all be used without application server as well**
  - Independent part of EJB 3 spec



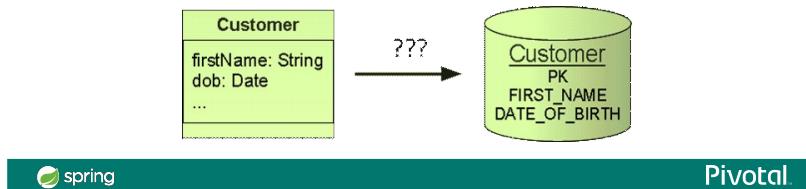
## Hibernate JPA

- Hibernate adds JPA support through an additional library
  - The *Hibernate EntityManager*
  - Hibernate sessions used behind JPA *interfaces*
  - Custom annotations for Hibernate specific extensions not covered by JPA
    - less important since JPA version 2



## JPA Mapping

- JPA requires metadata for mapping classes/fields to database tables/columns
  - Usually provided as annotations
  - XML mappings also supported ([orm.xml](#))
    - Intended for overrides only – not shown here
- JPA metadata relies on defaults
  - No need to provide metadata for the obvious



## What can you Annotate?



- Classes
  - Applies to the entire class (such as table properties)
- Fields
  - Typically mapped to a column
  - By default, *all* treated as persistent
    - Mappings will be defaulted
    - Unless annotated with `@Transient` (non-persistent)
  - Accessed directly via Reflection
- Properties (getters)
  - Also mapped to a column
  - Annotate getters instead of fields



## Mapping Using Fields (Data-Members)

```
@Entity  
@Table(name= "T_CUSTOMER")  
public class Customer {  
    @Id  
    @Column(name="cust_id")  
    private Long id;  
  
    @Column(name="first_name")  
    private String firstName;  
  
    @Transient  
    private User currentUser;  
    ...}
```

Mark as an *entity*  
Optionally override *table name*

Mark *id-field* (primary key)

Optionally override *column names*

Not stored in database

Data members set *directly*  
- using reflection  
- "field" access  
- no setters needed

Only @Entity and @Id are mandatory



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## Mapping Using Accessors (Properties)

```
public class Customer {  
    Must place @Id on the  
    getter method  
  
    Other annotations now also  
    placed on getter methods  
  
    @Entity @Table(name= "T_CUSTOMER")  
  
    private Long id;  
    private String firstName;  
  
    @Id  
    @Column (name="cust_id")  
    public Long getId()  
    { return this.id; }  
  
    @Column (name="first_name")  
    public String getFirstName()  
    { return this.firstName; }  
  
    public void setFirstName(String fn)  
    { this.firstName = fn; }  
}
```



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## Relationships

- Common relationship mappings supported
  - Single entities and entity collections both supported
  - Associations can be uni- or bi-directional

```
@Entity  
@Table(name= "T_CUSTOMER")  
public class Customer {  
    @Id  
    @Column (name="cust_id")  
    private Long id;  
  
    @OneToMany  
    @JoinColumn (name="cid")  
    private Set<Address> addresses;  
    ...  
}  
  
@Entity  
@Table(name= "T_ADDRESS")  
public class Address {  
    @Id private Long id;  
    private String street;  
    private String suburb;  
    private String city;  
    private String postcode;  
    private String country;  
}  
  
Foreign key in  
Address table
```



## Embeddables

- Map a table row to multiple classes
  - Address fields also columns in T\_CUSTOMER
  - @AttributeOverride overrides mapped column name

```
@Entity  
@Table(name= "T_CUSTOMER")  
public class Customer {  
    @Id  
    @Column (name="cust_id")  
    private Long id;  
  
    @Embedded  
    @AttributeOverride  
        (name="postcode", column=@Column(name="ZIP"))  
    private Address office;  
    ...  
}  
  
@Embeddable  
public class Address {  
    private String street;  
    private String suburb;  
    private String city;  
    private String postcode;  
    private String country;  
}  
  
Maps to ZIP  
column in  
T_CUSTOMER
```



## JPA Querying

- JPA provides several options for accessing data
  - Retrieve an object by primary key
  - Query for objects using JPA Query Language (JPQL)
    - Similar to SQL and HQL
  - Query for objects using Criteria Queries (appendix)
    - API for creating ad hoc queries
    - Only in JPA 2
  - Execute SQL directly to underlying database (appendix)
    - “Native” queries, allow DBMS-specific SQL to be used
    - Consider JdbcTemplate instead when not using managed objects – more options/control, more efficient



## JPA Querying: By Primary Key

- To retrieve an object by its database identifier simply call `find()` on the EntityManager

```
Long customerId = 123L;  
Customer customer = entityManager.find(Customer.class, customerId);
```

returns **null** if no object exists for the identifier

No cast required – JPA uses generics



## JPA Querying: JPQL

- SELECT clause required
- can't use \*

- Query for objects based on properties or associations ...

```
// Query with named parameters
TypedQuery<Customer> query = entityManager.createQuery(
    "select c from Customer c where c.address.city = :city", Customer.class);
query.setParameter("city", "Chicago");
List<Customer> customers = query.getResultList();

// ... or using a single statement
List<Customer> customers2 = entityManager.
    createQuery("select c from Customer c ...", Customer.class).
    setParameter("city", "Chicago").getResultList();

// ... or if expecting a single result
Customer customer = query.getSingleResult();
```

Specify Class to  
Populate / return

Can also use bind ? Variables  
– indexed from 1 like JDBC



## Topics in this session

- Introduction to JPA
  - General Concepts
  - Mapping
  - Querying
- **Configuring JPA in Spring**
- Implementing JPA DAOs
- Spring Data – JPA
- Lab
- Optional and Advanced Topics



# Quick Start – Spring JPA Configuration

## Steps to using JPA with Spring

1. Define an EntityManagerFactory bean.
2. Define a DataSource bean
3. Define a Transaction Manager bean
4. Define Mapping Metadata (already covered)
5. Define DAOs



Note: There are many configuration options for EntityManagerFactory, persistence.xml, and DataSource. See the optional section for details.



## Define the EntityManagerFactory

```
@Bean  
public LocalContainerEntityManagerFactoryBean entityManagerFactory() {  
  
    HibernateJpaVendorAdapter adapter = new HibernateJpaVendorAdapter();  
    adapter.setShowSql(true);  
    adapter.setGenerateDdl(true);  
    adapter.setDatabase(Database.HSQL);  
  
    Properties props = new Properties();  
    props.setProperty("hibernate.format_sql", "true");  
  
    LocalContainerEntityManagerFactoryBean emfb =  
        new LocalContainerEntityManagerFactoryBean();  
    emfb.setDataSource(dataSource);  
    emfb.setPackagesToScan("rewards.internal");  
    emfb.setJpaProperties(props);  
    emfb.setJpaVendorAdapter(adapter);  
  
    return emfb;  
}
```

*NOTE: no persistence.xml  
needed when using  
packagesToScan property*



## Configuration – XML Equivalent

```
<bean id="entityManagerFactory"
    class="org.springframework.orm.jpa.LocalContainerEntityManagerFactoryBean">
    <property name="dataSource" ref="dataSource"/>
    <property name="packagesToScan" value="rewards.internal"/>

    <property name="jpaVendorAdapter">
        <bean class="org.sfwk.orm.jpa.vendor.HibernateJpaVendorAdapter">
            <property name="showSql" value="true"/>
            <property name="generateDdl" value="true"/>
            <property name="database" value="HSQL"/>
        </bean>
    </property>

    <property name="jpaProperties">
        <props> <prop key="hibernate.format_sql">true</prop> </props>
    </property>
</bean>
```



## Define DataSource & Transaction Manager

```
@Bean
public LocalContainerEntityManagerFactoryBean entityManagerFactory() {
    LocalContainerEntityManagerFactoryBean emfb =
        new LocalContainerEntityManagerFactoryBean();
    emfb.setDataSource(dataSource());
    ...
    return emfb; // Method returns a FactoryBean...
}

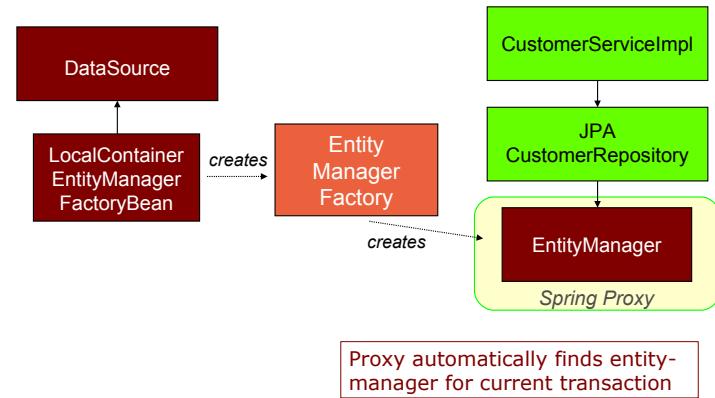
@Bean
public PlatformTransactionManager
    transactionManager(EntityManagerFactory emf) {
    return new JpaTransactionManager(emf);
}

@Bean
public DataSource dataSource() { // Lookup via JNDI or create locally. }
```

...Spring calls `getObjectType()` on the FactoryBean to obtain the EntityManagerFactory:



## EntityManagerFactoryBean Configuration



spring

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## Topics in this session

- Introduction to JPA
  - General Concepts
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  - Querying
- Configuring JPA in Spring
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- Optional and Advanced Topics

spring

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## Implementing JPA DAOs

- JPA provides configuration options so Spring can manage transactions via the EntityManager
- There are no Spring dependencies in your DAO implementations



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## Spring-Managed Transactions & EntityManager (1)

- To transparently participate in Spring-driven transactions
  - Define a transaction manager
    - Either `JpaTransactionManager`
    - Or `JtaTransactionManager`
  - Use FactoryBean for building the `EntityManagerFactory`
  - Inject `EntityManager` “proxy” with `@PersistenceContext`
    - JPA’s equivalent to `@Autowired`
    - At runtime the proxy resolves to current `EntityManager` for current transaction in current thread



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## Spring-Managed Transactions & EntityManager (2)

- The code – no Spring dependencies

```
public class JpaCustomerRepository implements CustomerRepository {  
    private EntityManager entityManager;  
  
    @PersistenceContext  
    public void setEntityManager (EntityManager entityManager) {  
        this.entityManager = entityManager;  
    }  
  
    public Customer findByld(long orderId) {  
        return entityManager.find(Customer.class, orderId);  
    }  
}
```

Automatic injection of EM Proxy

Proxy resolves to EM when used



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## Spring-managed Transactions and EntityManager (3)

- The Configuration

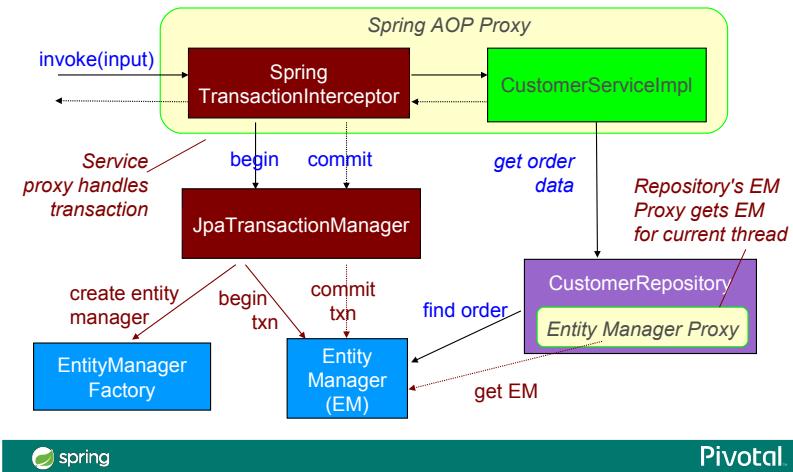
```
@Bean  
public LocalContainerEntityManagerFactoryBean entityManagerFactory() {  
    ...  
}  
  
@Bean  
public CustomerRepository jpaCustomerRepository() {  
    return new JpaCustomerRepository();  
}  
  
@Bean  
public PlatformTransactionManager  
transactionManager(EntityManagerFactory emf) throws Exception {  
    return new JpaTransactionManager(emf);  
}
```

Automatic injection of entity-manager proxy

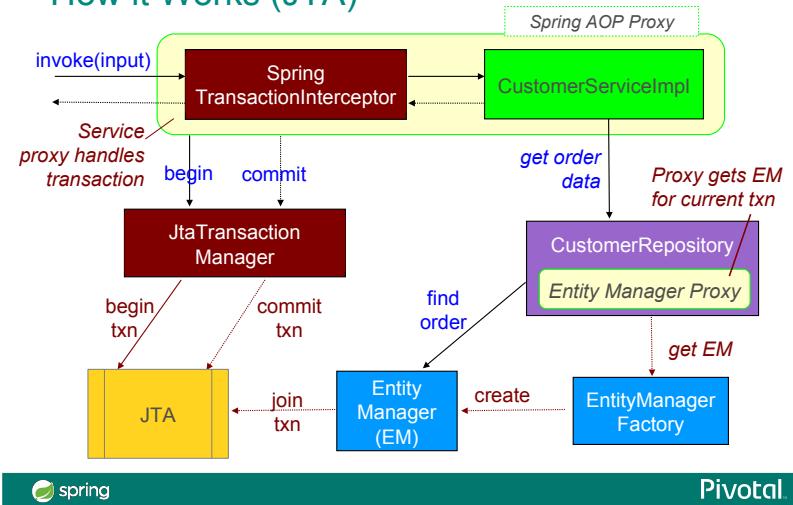


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## How it Works (JPA)



## How it Works (JTA)



## Topics in this session

- Introduction to JPA
  - General Concepts
  - Mapping
  - Querying
- Configuring JPA in Spring
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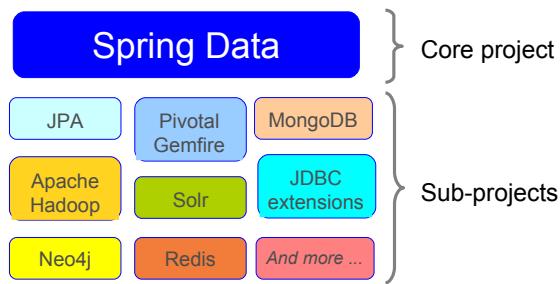
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## What is Spring Data?



SPRING DATA

- Reduces boiler plate code for data access
  - Works in many environments



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## Instant Repositories

- How?
  - **Step 1:** Annotate domain class
    - define keys & enable persistence
  - **Step 2:** Define your repository as an *interface*
- Spring will implement it at run-time
  - Scans for interfaces extending Spring's `Repository<T, K>`
  - CRUD methods auto-generated
  - Paging, custom queries and sorting supported
  - Variations exist for most Spring Data sub-projects



## Step 1: Annotate Domain Class

Here we are using JPA

- Annotate JPA Domain object as normal
  - Nothing to see here!

```
@Entity  
@Table(...)  
public class Customer {  
  
    @Id  
    @GeneratedValue(strategy = GenerationType.AUTO)  
    private Long id;  
    private Date oderDate;  
    private String email;  
  
    // Other data-members and getters and setters omitted  
}
```

Domain Class

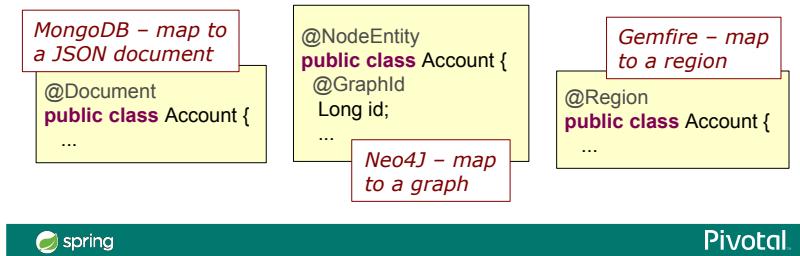
Note: Key is a Long





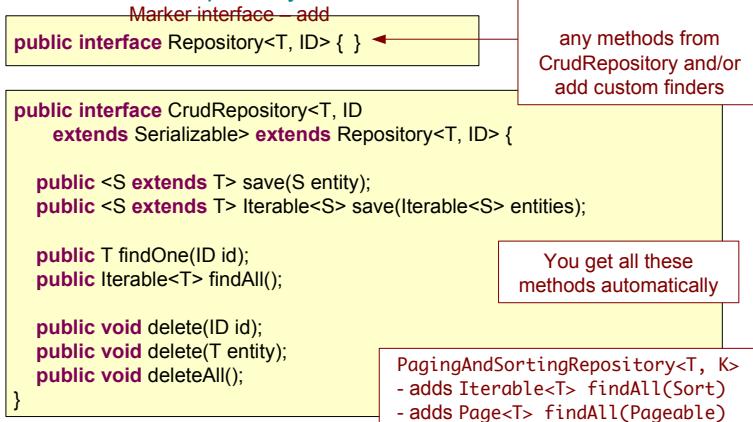
## Domain Objects: Other Data Stores

- Spring Data provides similar annotations to JPA
  - `@Document, @Region, @NodeEntity ...`
- Templates (like `JdbcTemplate`) for basic CRUD access
  - `MongoTemplate, GemfireTemplate, RedisTemplate ...`



## Step 2: Define a Repository Interface

Must extend `Repository<T, ID>`





## Generating Repositories

- Spring scans for Repository interfaces
  - Implements them and creates as a Spring bean
- Java Configuration

```
@Configuration  
@EnableJpaRepositories(basePackages="com.acme.**.repository")  
@EnableMongoRepositories(...)  
public class MyConfig { ... }
```

- XML

```
<jpa:repositories base-package="com.acme.**.repository" />  
<mongo:repositories base-package="com.acme.**.repository" />  
<gfe:repositories base-package="com.acme.**.repository" />
```



## Defining a JPA Repository

- Auto-generated finders obey naming convention
  - find(First)By<*DataMember*><*Op*>
  - <*Op*> can be GreaterThan, NotEquals, Between, Like ...

```
public interface CustomerRepository  
    extends CrudRepository<Customer, Long> {  
  
    public Customer findFirstByEmail(String someEmail); // No <Op> for Equals  
    public List<Customer> findByOrderDateLessThan(Date someDate);  
    public List<Customer> findByOrderDateBetween(Date d1, Date d2);  
  
    @Query("SELECT c FROM Customer c WHERE c.email NOT LIKE '%@%'")  
    public List<Customer> findInvalidEmails();  
}
```

Custom query uses query-language of underlying product (here JPQL)



## Convention over Configuration

Extend **Repository**  
and build your own  
interface using  
conventions.

- Note: Repository is an *interface* (*not a class!*)

```
import org.springframework.data.repository.Repository;  
import org.springframework.data.jpa.repository.Query;  
  
public interface CustomerRepository extends Repository<Customer, Long> {  
  
    <S extends Customer> save(S entity); // Definition as per CrudRepository  
    Customer findOne(long i); // Definition as per CrudRepository  
  
    Customer findFirstByEmailIgnoreCase(String email); // Case insensitive search  
  
    @Query("select u from Customer u where u.emailAddress = ?1")  
    Customer findByEmail(String email); // ?1 replaced by method param  
}
```



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## Internal Behavior – Another Spring Proxy

- Before startup

Interface  
CustomerRepository

- After startup

Interface  
CustomerRepository

implements

\$Proxy1

```
@Configuration  
@EnableJpaRepositories(basePackages="com.acme.repository")  
public class CustomerConfig { ... }
```

```
<jpa:repositories base-package="com.acme.repository"/>
```



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## Accessing the Repository

- Use Spring to inject *CustomerRepository* dependency

```
@Configuration  
@EnableJpaRepositories(basePackages="com.acme.repository")  
public class CustomerConfig {  
  
    @Autowired  
    public CustomerRepository customerRepository;  
  
    @Bean  
    public CustomerService customerService() {  
        return new CustomerService( customerRepository );  
    }  
}
```



## Summary

- Use 100% JPA to define entities and access data
  - Repositories have no Spring dependency
  - Spring Data Repositories need no code!
- Use Spring to configure JPA entity-manager factory
  - Smart proxy works with Spring-driven transactions
  - Optional translation to DataAccessExceptions (see advanced section)



# Lab

## Reimplementing Repositories using Spring and JPA

**Coming Up:** Optional topics on JPA queries, connection factories, DataAccessExceptions, custom Spring Data repositories



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### Topics in this session

- Introduction to JPA
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- Spring Data – JPA
- Lab
- **Optional and Advanced Topics**
  - JPA Typed Queries / Native Queries
  - EntityManagerFactoryBean alternatives / persistence.xml
  - Exception Translation
  - Customized Spring Data Repositories



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## JPA Querying: Typed Queries

- Criteria Query API (JPA 2)
  - Build type safe queries: fewer run-time errors
  - Much more verbose

```
public List<Customer> findByLastName(String lastName) {  
    CriteriaBuilder builder = entityManager.getCriteriaBuilder();  
    CriteriaQuery<Customer> cq = builder.createQuery(Customer.class);  
    Predicate condition =  
        builder.equal( cq.from(Customer.class).get(Customer_.name), lastName);  
    cq.where(condition);  
  
    return entityManager.createQuery(cq).getResultList();  
}
```

Meta-data class created by JPA (note underscore)



## JPA Querying: SQL

- Use a *native* query to execute raw SQL

```
// Query for multiple rows  
Query query = entityManager.createNativeQuery(  
    "SELECT cust_num FROM T_CUSTOMER c WHERE cust_name LIKE ?");  
query.setParameter(1, "%ACME%");  
List<String> customerNumbers = query.getResultList();  
  
// ... or if expecting a single result  
String customerNumber = (String) query.getSingleResult();  
  
// Query for multiple columns  
Query query = entityManager.createNativeQuery(  
    "SELECT ... FROM T_CUSTOMER c WHERE ...", Customer.class);  
List<Customer> customers = query.getResultList();
```

No named parameter support

Indexed from 1 - like JDBC

Specify Class to Populate / return



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## Setting up an EntityManagerFactory

- Three ways to set up an EntityManagerFactory:
  - LocalEntityManagerFactoryBean
  - LocalContainerEntityManagerFactoryBean
  - Use a JNDI lookup
- **persistence.xml** required for configuration
  - From version 3.1, Spring allows no *persistence.xml* with LocalContainerEntityManagerFactoryBean



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## persistence.xml

## <?xml?>

- Always stored in META-INF
- Specifies “persistence unit”:
  - optional vendor-dependent information
  - DB Connection properties often specified here.

```
<persistence version="1.0"
    xmlns="http://java.sun.com/xml/ns/persistence"
    xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
    xsi:schemaLocation="http://java.sun.com/xml/ns/persistence
        http://java.sun.com/xml/ns/persistence/persistence_1_0.xsd">
    <persistence-unit name="rewardNetwork"/>
    ...
</persistence>
```

- File is required in JPA, but optional when using Spring with JPA!



## LocalEntityManagerFactoryBean

- Useful for standalone apps, integration tests
- Cannot specify a DataSource
  - Useful when only data access is via JPA
  - Uses standard JPA service location (SPI) mechanism

/META-INF/services/javax.persistence.spi.PersistenceProvider

```
@Bean
public LocalEntityManagerFactoryBean entityManager() {
    LocalEntityManagerFactoryBean em =
        new LocalEntityManagerFactoryBean();
    em.setPersistenceUnitName("rewardNetwork");
    return em;
}
```



## LocalContainer EntityManagerFactoryBean

- Provides full JPA capabilities
- Integrates with existing DataSources
- Useful when fine-grained customization needed
  - Can specify vendor-specific configuration

We saw this earlier using  
100% Spring configuration  
In both XML and Java



## Configuration – Spring Persistence Unit

```
@Bean
public LocalContainerEntityManagerFactoryBean entityManagerFactory() {
    LocalContainerEntityManagerFactoryBean emfb =
        new LocalContainerEntityManagerFactoryBean();
    emfb.setDataSource(dataSource);
    emfb.setPersistenceUnitName("rewardNetwork");
    return emfb;
}
```

Do JPA config in *persistence.xml*

```
<persistence-unit name="rewardNetwork">
    <provider>org.hibernate.ejb.HibernatePersistence</provider>
    <properties>
        <property name="hibernate.dialect"
                 value="org.hibernate.dialect.HSQLDialect"/>
        <property name="hibernate.hbm2ddl.auto" value="create"/>
        <property name="hibernate.show_sql" value="true" />
        <property name="hibernate.format_sql" value="true" />
    </properties>
</persistence-unit>
```

If using JTA – declare *<jta-data-source>* in the persistence-unit

Minimal Spring config



## JNDI Lookups

- A jee:jndi-lookup can be used to retrieve *EntityManagerFactory* from application server
- Useful when deploying to JEE Application Servers (WebSphere, WebLogic, etc.)

```
@Bean  
public EntityManagerFactory entityManagerFactory() throws Exception {  
    Context ctx = new InitialContext();  
    return (DataSource) ctx.lookup("persistence/rewardNetwork");  
}
```

OR

```
<jee:jndi-lookup id="entityManagerFactory"  
    jndi-name="persistence/rewardNetwork"/>
```



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## Topics in this session

- Introduction to JPA
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  - JPA Typed Queries / Native Queries
  - EntityManagerFactoryBean alternatives / persistence.xml
  - **Exception Translation**
  - Customized Spring Data Repositories



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## Transparent Exception Translation (1)

- Used as-is, the DAO implementations described earlier will throw unchecked JPA PersistenceExceptions
  - Not desirable to let these propagate up to the service layer or other users of the DAOs
  - Introduces dependency on the specific persistence solution that should not exist
- AOP allows translation to Spring's rich, vendor-neutral DataAccessException hierarchy
  - Hides access technology used



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## Transparent Exception Translation (2)

- Spring provides this capability out of the box
  - Annotate with `@Repository`
  - Define a Spring-provided BeanPostProcessor

```
@Repository  
public class JpaCustomerRepository implements CustomerRepository {  
    ...  
}
```

```
<bean class="org.springframework.dao.annotation.  
PersistenceExceptionTranslationPostProcessor"/>
```



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## Transparent Exception Translation (3)

- Or use XML configuration:

```
public class JpaCustomerRepository implements CustomerRepository {  
    ...  
}
```

No annotations

```
<bean id="persistenceExceptionInterceptor"  
      class="org.springframework.dao.support.  
          PersistenceExceptionTranslationInterceptor"/>  
  
<aop:config>  
    <aop:advisor pointcut="execution(* *..CustomerRepository+.*(..))"  
        advice-ref="persistenceExceptionInterceptor" />  
</aop:config>
```



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## Topics in this session

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## JPA Specific Interface

- Adds EntityManager specific options

```
public interface JpaRepository<T, ID extends Serializable>
    extends PagingAndSortingRepository<T, ID> {

    <S extends T> S saveAndFlush(S entity);
    void flush();

    // Implemented as a single DELETE
    void deleteInBatch(Iterable<T> entities);
    void deleteAllInBatch();

    // Returns a lazy-loading proxy, using JPA's EntityManager.getReference()
    // – equivalent to Hibernate's Session.load()
    T getOne(ID id);
}
```



## Adding Custom Behavior (1)

- Not all use cases satisfied by automated methods
  - Enrich with custom repositories: *mix-ins*
- **Step 1:** Create normal interface and implementation

```
public class CustomerRepositoryImpl implements CustomerRepositoryCustom {
    Customer findDeadbeatCustomers() {
        // Your custom implementation to find unreliable
        // and bad-debt customers
    }
}

public interface CustomerRepositoryCustom {
    Customer findDeadbeatCustomers();
}
```



## Adding Custom Behavior (2)

- **Step 2:** Combine with an automatic repository:

```
public interface CustomerRepository  
    extends CrudRepository<Account, Long>, CustomerRepositoryCustom {  
}
```

- Spring Data looks for implementation beans
  - ID = repository interface + “Impl” (configurable)
  - In this example: “CustomerRepositoryImpl”
- Result: *CustomerRepository* bean contains automatic and custom methods!



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## Topics Covered

- Introduction to JPA
- Configuring JPA in Spring
- Implementing JPA DAOs
- Spring Data – JPA
- Advanced
  - JPA Typed Queries / Native Queries
  - EntityManagerFactoryBean alternatives and persistence.xml
  - Exception Translation
  - Customized Spring Data Repositories



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# Overview of Spring Web

Developing Modern Web Applications

Servlet Configuration, Product Overview

## Topics in this Session

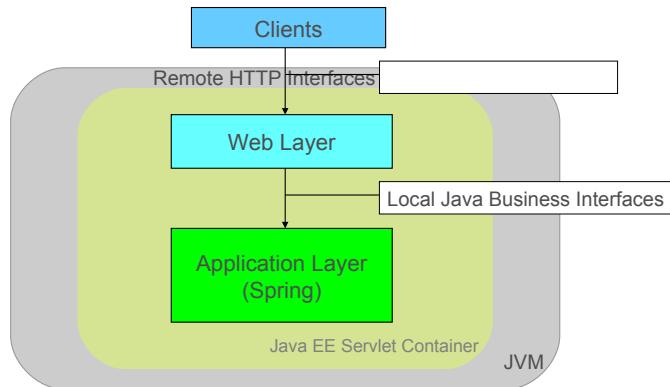
- **Introduction**
- Using Spring in Web Applications
- Overview of Spring Web
- Spring and other Web frameworks

## Web Layer Integration

- Spring provides support in the Web layer
  - Spring MVC, Spring WebFlow...
- However, you are free to use Spring with any Java web framework
  - Integration might be provided by Spring or by the other framework itself
  - Spring also integrates with many of the common REST frameworks



## Effective Web Application Architecture



## Topics in this Session

- Introduction
- **Using Spring in Web Applications**
- Overview of Spring Web
- Spring and other Web frameworks



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## Spring Application Context Lifecycle in Web Applications

- Spring can be initialized within a webapp
  - start up business services, repositories, etc.
- Uses a standard servlet listener
  - initialization occurs before any servlets execute
  - application ready for user requests
  - `ApplicationContext.close()` is called when the application is stopped



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## Configuration via WebApplicationInitializer

```
public class MyWebAppInitializer  
    extends AbstractContextLoaderInitializer {  
  
    @Override  
    protected WebApplicationContext createRootApplicationContext() {  
  
        // Create the 'root' Spring application context  
        AnnotationConfigWebApplicationContext rootContext =  
            new AnnotationConfigWebApplicationContext();  
  
        rootContext.getEnvironment().setActiveProfiles("jpa"); // optional  
        rootContext.register(RootConfig.class);  
        return rootContext;  
    }  
    ...  
}
```

Implements *WebApplicationInitializer*  
Automatically detected by servlet container.

Multiple classes may be listed

Available in Servlet 3.0+ Environments, no more web.xml!



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## Configuration via web.xml

- Only option prior to servlet 3.0
  - Just add a Spring-provided servlet listener

```
<context-param>  
    <param-name>contextConfigLocation</param-name>  
    <param-value>  
        /WEB-INF/merchant-reporting-webapp-config.xml  
    </param-value>  
</context-param>
```

The application context's configuration file(s)

```
<listener>  
    <listener-class>  
        org.springframework.web.context.ContextLoaderListener  
    </listener-class>  
</listener>
```

Loads the ApplicationContext into the ServletContext before any Servlets are initialized



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## web.xml Configuration Options

- Default resource location is document-root
  - Can use **classpath:** designator
  - Defaults to WEB-INF/applicationContext.xml

```
<context-param>
    <param-name>contextConfigLocation</param-name>
    <param-value>
        classpath:/rewards/internal/application-config.xml
        /WEB-INF/merchant-reporting-webapp-config.xml
    </param-value>
</context-param>
<context-param>
    <param-name>spring.profiles.active</param-name>
    <param-value>jpa</param-value>
</context-param>
```

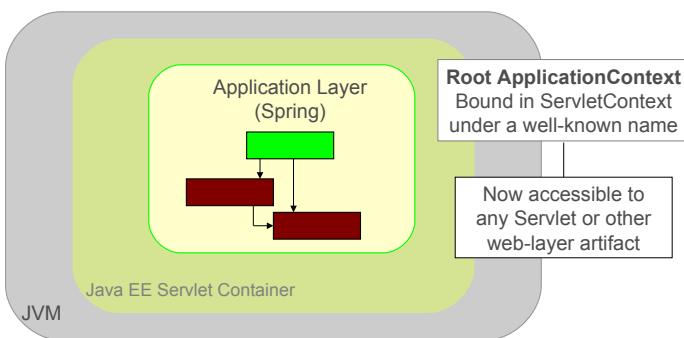
web.xml

Optionally specify profile(s) to use



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## Servlet Container After Starting Up



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## Instantiating Servlets

- Override `onStartup()` method to define servlets
  - Warning: Can't access Spring beans, not available yet

```
public class MyWebAppInitializer extends AbstractContextLoaderInitializer {  
  
    protected WebApplicationContext createRootApplicationContext() {  
        // ...Same configuration as previous slide...  
    }  
  
    public void onStartup(ServletContext container) {  
        super.onStartup(container);  
        // Register and map a servlet  
        ServletRegistration.Dynamic svlt =  
            container.addServlet("myServlet", new TopSpendersReportGenerator());  
        svlt.setLoadOnStartup(1);  
        svlt.addMapping("/");  
    }  
}
```

No beans are loaded yet at this point in the lifecycle...



## Dependency Injection of Servlets

- Suitable for `web.xml` or `AbstractContextLoaderInitializer`
- Use `WebApplicationContextUtils`
  - gets Spring `ApplicationContext` from `ServletContext`

```
public class TopSpendersReportGenerator extends HttpServlet {  
    private ClientService clientService;  
  
    public void init() {  
        ApplicationContext context = WebApplicationContextUtils.  
            getRequiredWebApplicationContext(getServletContext());  
        clientService = (ClientService) context.getBean("clientService");  
    }  
    ...  
}
```



## Spring MVC Supports Dependency Injection

- Example using Spring MVC

```
@Controller  
public class TopSpendersReportController {  
    private ClientService clientService;  
  
    @Autowired  
    public TopSpendersReportController(ClientService service) {  
        this.clientService = service;  
    }  
    ...  
}
```



No need for *WebApplicationContextUtils* anymore



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## Topics in this Session

- Introduction
- Using Spring in Web Applications
- **Overview of Spring Web**
- Spring and other Web frameworks



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## Spring Web

- Spring MVC
  - Web framework bundled with Spring
- Spring WebFlow
  - Plugs into Spring MVC
  - Implements navigation flows
- Spring Mobile
  - Routing between mobile / non-mobile versions of site
- Spring Social
  - Easy integration with Facebook, Twitter, etc.



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## Spring Web MVC

- Spring's web framework
  - Uses Spring for its own configuration
  - Controllers are Spring beans
  - testable artifacts
- Annotation-based model since Spring 2.5
- Builds on the Java Servlet API
- The core platform for developing web applications with Spring
  - All higher-level modules such as WebFlow build on it



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# Spring Web Flow

- Plugs into Spring Web MVC as a Controller technology for implementing stateful "flows"
  - Checks that users follow the right navigation path
  - Manages back button and multiple windows issues
  - Provides scopes beyond request and session
    - such as the *flow* and *flash* scope
  - Addresses the double-submit problem elegantly



## Example Flow Definition Online Check-in

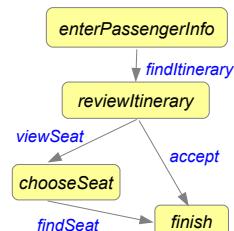
- Flows are declared in Xml

```
<flow ...>
  <view-state id="enterPassengerInfo">
    <transition on="findItinerary" to="reviewItinerary" />
  </view-state>

  <view-state id="reviewItinerary">
    <transition on="viewSeat" to="chooseSeat" />
    <transition on="accept" to="finish" />
  </view-state>

  <view-state id="chooseSeat">
    <transition on="findSeat" to="finish" />
  </view-state>

  <end-state id="finish">
  </flow>
```



## More about WebFlow

- Online sample application is available here:  
<http://richweb.springsource.org/swf-booking-faces/spring/intro>
- Sample applications can be downloaded here:  
<http://projects.spring.io/spring-webflow/>



The screenshot shows a Firefox browser window displaying the "Spring Faces: Hotel Booking Sample Application". The title bar reads "Spring Faces: Hotel Booking Sample Application - Mozilla Firefox". The main content area shows a search results table titled "Hotel Results". The table has columns: Name, Address, City, State, Zip, and Action. The data includes:

Name	Address	City, State	Zip	Action
Westin Diplomat	3555 S. Ocean Drive	Hollywood, FL, USA	33019	<a href="#">View Hotel</a>
Jameson Inn	890 Palm Bay Rd NE	Palm Bay, FL, USA	32905	<a href="#">View Hotel</a>
Chilworth Manor	The Cottage, Southampton Business Park	Southampton, Hants, UK	SO16 7JF	<a href="#">View Hotel</a>
Marriott Courtyard	Tower Place, Buckhead	Atlanta, GA, USA	30305	<a href="#">View Hotel</a>
Doubletree	Tower Place, Buckhead	Atlanta, GA, USA	30305	<a href="#">View Hotel</a>

At the bottom right of the table, there is a link "More Results".

On the left side of the browser window, there is a sidebar with a large image of a modern hotel building and the text "THE SPRING EXPERIENCE".

On the right side of the browser window, there is a vertical sidebar with some icons.

At the bottom of the browser window, there is a toolbar with standard file operations: File, Edit, View, History, Delicious, Bookmarks, Yahoo!, Tools, Help.

At the very bottom of the slide, there are two logos: "spring" on the left and "Pivotal" on the right.

## Topics in this Session

- Introduction
- Using Spring in Web Applications
- Overview of Spring Web
- **Spring and other Web frameworks**



The screenshot shows a portion of the "Spring Faces: Hotel Booking Sample Application" interface. It displays a table titled "Hotel Results" with several rows of data. The table columns are: Name, Address, City, State, Zip, and Action. The data includes:

Name	Address	City, State	Zip	Action
Westin Diplomat	3555 S. Ocean Drive	Hollywood, FL, USA	33019	<a href="#">View Hotel</a>
Jameson Inn	890 Palm Bay Rd NE	Palm Bay, FL, USA	32905	<a href="#">View Hotel</a>
Chilworth Manor	The Cottage, Southampton Business Park	Southampton, Hants, UK	SO16 7JF	<a href="#">View Hotel</a>
Marriott Courtyard	Tower Place, Buckhead	Atlanta, GA, USA	30305	<a href="#">View Hotel</a>
Doubletree	Tower Place, Buckhead	Atlanta, GA, USA	30305	<a href="#">View Hotel</a>

At the bottom right of the table, there is a link "More Results".

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At the very bottom of the slide, there are two logos: "spring" on the left and "Pivotal" on the right.

## Spring – Struts 2 Integration

### Java Configuration

```
@Action("/doLogin")
@ResultPath("/WEB-INF/views")
@Result(name = "success", location = "LoginSuccess.jsp"),
@Result(name = "error", location = "LoginError.jsp")
public class DoLoginAction extends ActionSupport {
    @Autowired
    private UserDAO userDAO;
    private User user;
    ...

    public String execute() {
        if (userDAO.checkLogin(user)) { return SUCCESS; }

        return ERROR;
    }
}
```

Inject Spring Beans in  
The normal way



## Spring – Struts 2 Integration

### XML Configuration

- Integration plug-in provided by Struts 2 framework

```
<struts>
    <!-- Define Spring as the object factory -->
    <constant name="struts.objectFactory" value="spring" />
    ...
</struts>
```

```
<struts>
    <include file="struts-default.xml"/>

    <package name="secure" namespace="/secure" extends="default">
        <action name="example" class="myBean">
            <result>example.ftl</result>
        </action>
    </package>
</struts>
```

class actually specifies  
a Spring bean name



## Spring – JSF Integration

- Two options
  - Spring-centric integration
    - Provided by Spring Faces sub-project of Spring Web Flow
  - JSF-centric integration
    - Spring plugs in as the JSF managed bean provider

```
<managed-bean>
<managed-bean-name>userList</managed-bean-name>
<managed-bean-class>com.springsource.web.ClientController</managed-bean-class>
<managed-bean-scope>request</managed-bean-scope>
<managed-property>
<property-name>userManager</property-name>
<value>#{userManager}</value>
</managed-property>
```

*JSF-centric integration*



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## Integration with Other Frameworks

- Wicket
  - Comes with an integration to Spring  
<https://cwiki.apache.org/confluence/display/WICKET/Spring>
- Tapestry 5
  - Provides a dedicated integration module for Spring  
<https://tapestry.apache.org/integrating-with-spring-framework.html>



tapestry



APACHE WICKET



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## Summary

- Spring can be used with any web framework
  - Spring provides the ContextLoaderListener that can be declared in web.xml
- Spring MVC is a lightweight web framework where controllers are Spring beans
  - More about Spring MVC in the next module
- WebFlow plugs into Spring MVC as a Controller technology for implementing stateful "flows"



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# Spring Web MVC Essentials

## Getting Started With Spring MVC

Implementing a Simple Controller

## What is Spring MVC?

- Web framework based on the Model/View/Controller pattern
  - Alternative to JSF, Struts 1, Struts 2 (WebWork), Tapestry, Wicket ...
- Based on Spring principles
  - POJO programming
  - Testable components
  - Uses Spring for configuration
- Supports a wide range of view technologies
  - JSP, XSLT, PDF, Excel, Velocity, Freemarker, Thymeleaf, etc.

## Topics in this Session

- Request Processing Lifecycle
- Key Artifacts
  - DispatcherServlet
  - Controllers
  - Views
- Quick Start



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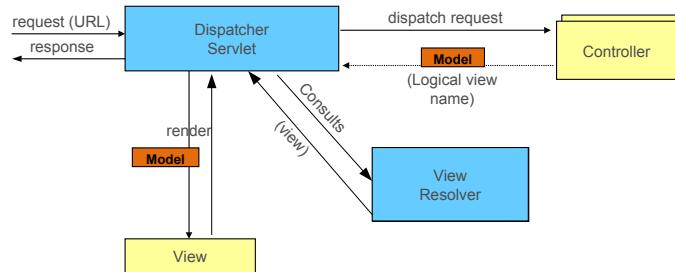
## Web Request Handling Overview

- Web request handling is rather simple
  - Based on an incoming URL...
  - ...we need to call a method...
  - ...after which the return value (if any)...
  - ...needs to be rendered using a view



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## Request Processing Lifecycle



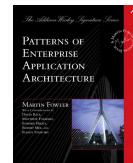
## Topics in this Session

- Request Processing Lifecycle
- **Key Artifacts**
  - DispatcherServlet
  - Controllers
  - Views
- Quick Start



## DispatcherServlet: The Heart of Spring Web MVC

- A “front controller”
  - coordinates all request handling activities
  - analogous to Struts ActionServlet / JSF FacesServlet
- Delegates to Web infrastructure beans
- Invokes user Web components
- Fully customizable
  - interfaces for all infrastructure beans
  - many extension points



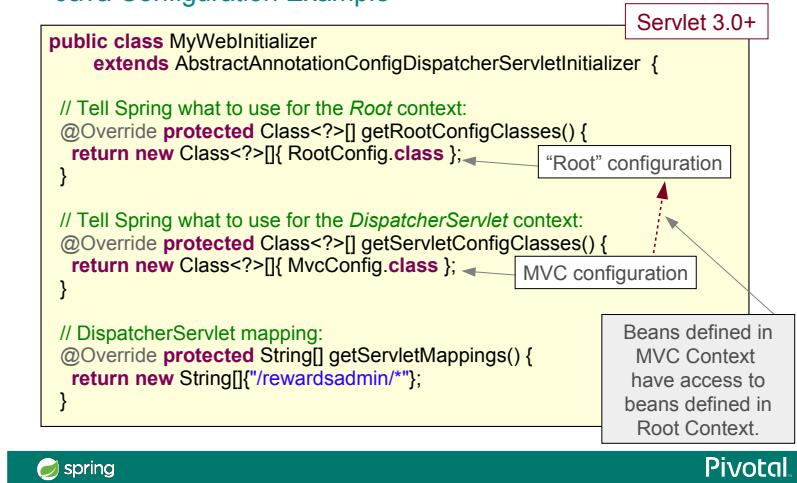
## DispatcherServlet Configuration

- Defined by `WebApplicationInitializer` OR `web.xml`
- Uses Spring for its configuration
  - programming to interfaces + dependency injection
  - easy to swap parts in and out
- Creates separate “servlet” application context
  - configuration is private to DispatcherServlet
- Full access to the parent “root” context
  - instantiated via ContextLoaderListener
    - shared across servlets

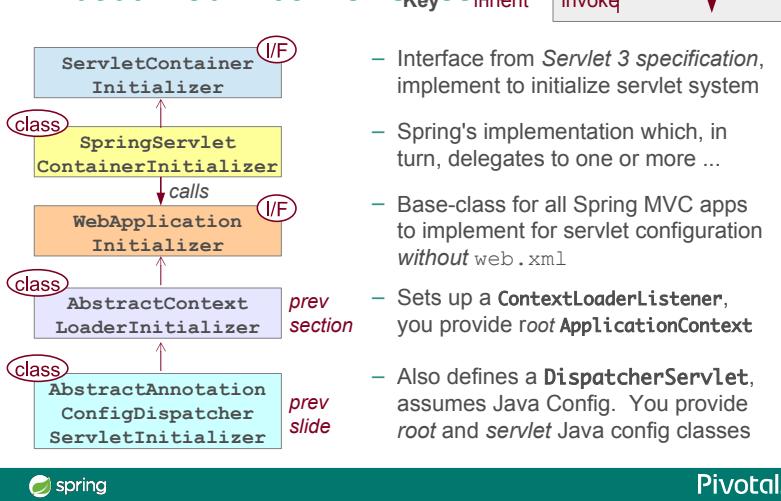


## Dispatcher Servlet

### Java Configuration Example



## About Web Initializer Classes



## Dispatcher Servlet XML Configuration Example

```
<servlet>
    <servlet-name>main</servlet-name>
    <servlet-class>
        org.springframework.web.servlet.DispatcherServlet
    </servlet-class>
    <init-param>
        <param-name>contextConfigLocation</param-name>
        <param-value>/WEB-INF/spring/web-config.xml</param-value>
    </init-param>
</servlet>

<servlet-mapping>
    <servlet-name>main</servlet-name>
    <url-pattern>/rewardsadmin/*</url-pattern>
</servlet-mapping>
```

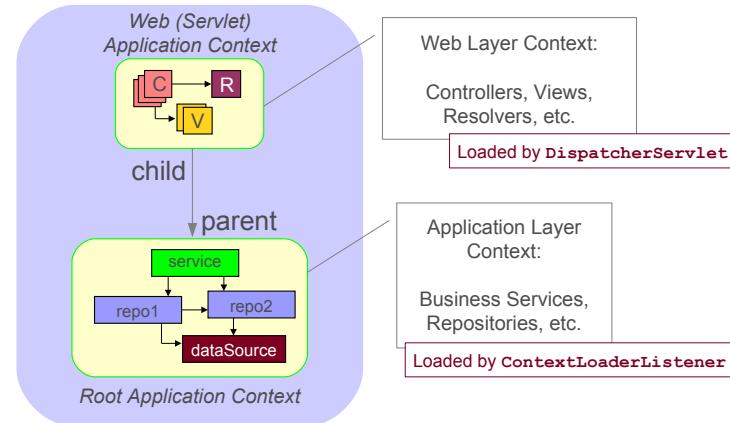
Pre-Servlet 3.0

web.xml

Beans defined in web context have access to beans defined in RootApplicationContext



## Servlet Container After Starting Up



## Topics in this Session

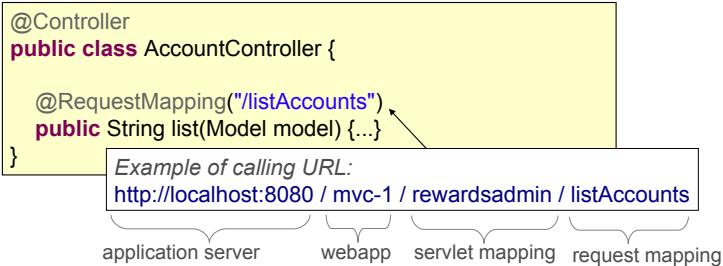
- Request Processing Lifecycle
- Key Artifacts
  - DispatcherServlet
  - **Controllers**
  - Views
- Quick Start



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## Controller Implementation

- Annotate controllers with `@Controller`
  - `@RequestMapping` tells Spring what method to execute when processing a particular request



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## URL-Based Mapping Rules

- Mapping rules typically URL-based, optionally using wild cards:
    - /accounts
    - /accounts/edit
    - /editAccount
    - /listAccounts.htm
    - /accounts/\*
- Suffixes *ignored* by default



## Controller Method Parameters

- Extremely flexible!
- You pick the parameters you need, Spring provides them
  - HttpServletRequest, HttpSession, Principal ...
  - Model for sending data to the view.
  - See [Spring Reference, Handler Methods](#)

```
@Controller  
public class AccountController {  
  
    @RequestMapping("/listAccounts")  
    public String list(Model model) {  
        ...  
    }  
}
```

View name

Model holds data for view



## Extracting Request Parameters

- Use `@RequestParam` annotation
  - Extracts parameter from the request
  - Performs type conversion

```
@Controller  
public class AccountController {  
  
    @RequestMapping("/showAccount")  
    public String show(@RequestParam("entityId") long id,  
                      Model model) {  
        ...  
    }  
}
```

*Example of calling URL:*

`http://localhost:8080/mvc-1/rewardsadmin/showAccount.htm?entityId=123`



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## URI Templates

- Values can be extracted from request URLs
  - *Based on URI Templates*
  - not Spring-specific concept, used in many frameworks
  - Use `{...}` placeholders and `@PathVariable`
- Allows clean URLs without request parameters

```
@Controller  
public class AccountController {  
  
    @RequestMapping("/accounts/{accountId}")  
    public String show(@PathVariable("accountId") long id,  
                      Model model) {  
        ...  
    }  
}
```

*Example of calling URL:*

`http://localhost:8080/mvc-1/rewardsadmin/accounts/123`



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## Method Signature Examples

Example URLs

```
@RequestMapping("/accounts")
```

<http://.../accounts>

```
public String show(HttpServletRequest request, Model model)
```

```
@RequestMapping("/orders/{id}/items/{itemId}")
```

<http://.../orders/1234/items/2>

```
public String show(@PathVariable("id") Long id,
```

```
    @PathVariable int itemId,
```

```
    Model model, Locale locale,
```

```
    @RequestHeader("user-agent") String agent )
```

```
@RequestMapping("/orders")
```

<http://.../orders?id=1234&itemId=2>

```
public String show(@RequestParam Long id,
```

```
    @RequestParam("itemId") int itemId,
```

```
    Principal user, Map<String, Object> model,
```

```
    HttpSession session )
```

View name



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## Topics in this Session

- Request Processing Lifecycle
- Key Artifacts
  - DispatcherServlet
  - Controllers
  - Views
- Quick Start



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## Views

- A **View** renders web output.
  - Many built-in views available for JSPs, XSLT, templating approaches (Velocity, FreeMarker), etc.
  - View support classes for creating PDFs, Excel spreadsheets, etc.
- Controllers typically return a 'logical view name' String.
- **ViewResolvers** select View based on view name.



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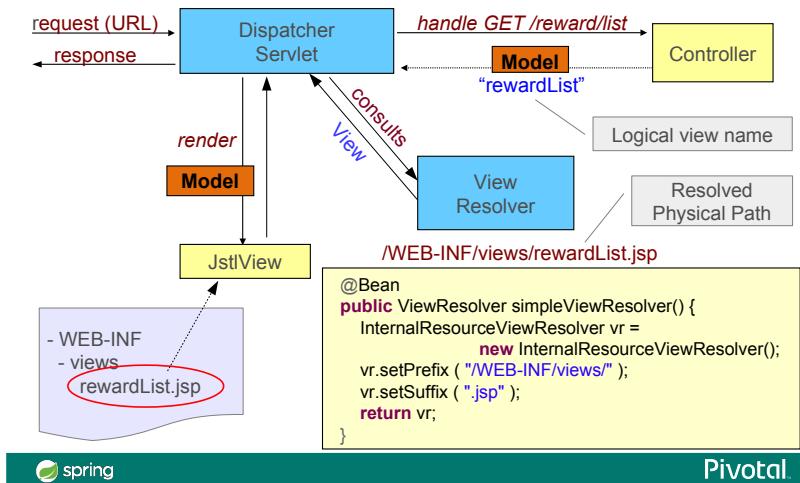
## View Resolvers

- The DispatcherServlet delegates to a **ViewResolver** to obtain **View** implementation based on view name.
- The default ViewResolver treats the view name as a Web Application-relative file path
  - i.e. a JSP: `/WEB-INF/reward/list.jsp`
- Override this default by registering a ViewResolver bean with the DispatcherServlet
  - We will use **InternalResourceViewResolver**
  - Several other options available.



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## Internal Resource View Resolver Example



## Topics in this Session

- Request Processing Lifecycle
- Key Artifacts
  - DispatcherServlet
  - Controllers
  - Views
- Quick Start

## Quick Start

Steps to developing a Spring MVC application

1. Deploy a Dispatcher Servlet (one-time only)
2. Implement a controller
3. Register the Controller with the DispatcherServlet
4. Implement the View(s)
5. Register a ViewResolver (optional, one-time only)
6. Deploy and test

Repeat steps 2-6 to develop new functionality



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### 1a. Deploy DispatcherServlet

```
public class WebInitializer  
    extends AbstractAnnotationConfigDispatcherServletInitializer {  
  
    // Root context:  
    @Override protected Class<?>[] getRootConfigClasses() {  
        return new Class<?>[]{ RootConfig.class };  
    }  
    // DispatcherServlet context:  
    @Override protected Class<?>[] getServletConfigClasses() {  
        return new Class<?>[]{ MvcConfig.class };  
    }  
    // DispatcherServlet mapping:  
    @Override protected String[] getServletMappings() {  
        return new String[]{ "/rewardsadmin/**" };  
    }  
}
```

Services, Repositories ...

Contains Spring MVC configuration



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## 1b. Deploy DispatcherServlet

- Can handle URLs like ...

```
http://localhost:8080/mvc-1/rewardsadmin/reward/list  
http://localhost:8080/mvc-1/rewardsadmin/reward/new  
http://localhost:8080/mvc-1/rewardsadmin/reward/show?id=1
```

- We will implement *show*



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## Initial Spring MVC Configuration

```
@Configuration  
@EnableWebMvc  
public class MvcConfig {  
  
    // No beans required for basic Spring MVC usage.  
  
}
```

Sets up Spring MVC with convenient defaults  
– see Advanced section for full details

Spring MVC *automatically* defines several beans.

Only need to provide additional beans and/or  
overrides to default beans (if desired)

- For example: view resolvers



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## 2. Implement the Controller

```
@Controller  
public class RewardController {  
    private RewardLookupService lookupService;  
  
    @Autowired  
    public RewardController(RewardLookupService svc) {  
        this.lookupService = svc;  
    }  
  
    @RequestMapping("/reward/show")  
    public String show(@RequestParam("id") long id,  
                      Model model) {  
        Reward reward = lookupService.lookupReward(id);  
        model.addAttribute("reward", reward);  
        return "rewardView";  
    }  
}
```

Depends on application service

Automatically filled in by Spring

Selects the "rewardView" to render the reward



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## 3. Register the Controller

```
@Configuration  
@EnableWebMvc  
@ComponentScan("accounts.web")  
public class MvcConfig() {  
}
```

- Component-scanning very effective for MVC controllers!
- Be specific when indicating base package, avoid loading non-web layer beans
- Feel free to use <bean /> or @Configuration approaches as desired



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## 4. Implement the View

```
<html>
  <head><title>Your Reward</title></head>
  <body>
    Amount=${reward.amount} <br/>
    Date=${reward.date} <br/>
    Account Number=${reward.account} <br/>
    Merchant Number=${reward.merchant}
  </body>
</html>
```

References result model object by name

/WEB-INF/views/rewardView.jsp

Note: no references to Spring object / tags required in JSP.



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## 5. Register ViewResolver

```
@Configuration
@EnableWebMvc
@ComponentScan("accounts.web")
public class MvcConfig {

  @Bean
  public ViewResolver simpleViewResolver() {
    InternalResourceViewResolver vr =
      new InternalResourceViewResolver();
    vr.setPrefix ( "/WEB-INF/views/" );
    vr.setSuffix ( ".jsp" );
    return vr;
  }
}
```

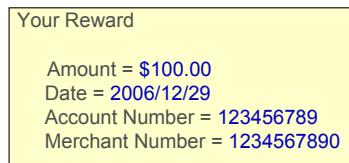
• Controller returns rewardList  
• ViewResolver converts to /WEB-INF/views/rewardList.jsp



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## 6. Deploy and Test

`http://localhost:8080/rewardsadmin/reward/show?id=1`



## Summary

- Spring MVC is Spring's web framework
  - @Controller classes handle HTTP requests
  - URL information available
    - @RequestParam, @PathVariable
  - Data returned via the Model
  - Output (HTML) generated by Views
- Multiple View technologies supported
  - ViewResolvers define where Views can be found

*Learn More:*  
[Spring-Web – 4 day course on Spring Web Modules](#)



# Lab

## Adding a Web Interface

Coming Up: `@EnableWebMvc`



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## MVC Additions in Spring 3.x and 4.x

- `@MVC` and legacy Controllers enabled by default
  - Appropriate Controller Mapping and Adapters registered out-of-the-box
- Newer features *not* enabled by default
  - Stateless converter framework for binding & formatting
  - Support for JSR-303 declarative validation for forms
  - `HttpMessageConverters` (for RESTful web services)
- *How do you use these features?*



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## @EnableWebMvc

- Registers Controller Mapping/Adapter for @MVC only
  - You lose legacy default mappings and adapters!
  - Enables custom conversion service and validators
  - Beyond scope of this course

```
@Configuration  
@EnableWebMvc  
public class RewardConfig {  
  
    @Bean  
    public rewardController(RewardLookupService service) {  
        return new RewardController(service);  
    }  
    ...  
}
```



## WebMvcConfigurerAdapter

- Optionally extend WebMvcConfigurerAdapter
  - Override methods to define/customize web-beans

```
@Configuration  
@EnableWebMvc  
public class RewardConfig extends WebMvcConfigurerAdapter {  
  
    @Bean public rewardController(RewardLookupService service) { ... }  
  
    @Override  
    public void addFormatters(FormatterRegistry registry) {  
        // Register your own type converters and formatters...  
    }  
    ...  
}
```

Example: add  
custom formatters



## MVC Namespace

- XML Equivalent to @EnableWebMvc

```
<beans xmlns="http://www.springframework.org/schema/beans"
       xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
       xmlns:mvc="http://www.springframework.org/schema/mvc"
       xsi:schemaLocation="...>

    <!-- Provides default conversion service, validator and message converters -->
    <mvc:annotation-driven/>
```

*Learn More:*  
[Spring-Web – 4 day course on Spring Web Modules](#)



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## Older Versions of Spring MVC

- Spring MVC is highly backwards compatible
  - Most default settings have remained unchanged since Spring 2.5 (versions 3.0, 3.1, 3.2, 4.0, 4.1, 4.2, 4.3 ... !)
- However, old default settings are no longer recommended
  - Newer styles of controllers, adapters, message convertors, validators ...
- To enable the more modern set of defaults
  - **Use Spring Boot**
  - *Or use @EnableWebMvc or <mvc:annotation-config/> explicitly*



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# Spring Boot - Basics

## Getting started with Spring Boot

Starter POMs, Auto-Configuration



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## What is Spring Boot?

- Spring Applications typically require a lot of setup
  - Consider working with JPA. You need:
    - Datasource, TransactionManager, EntityManagerFactory ...
  - Consider a web MVC app. You need:
    - WebApplicationInitializer / web.xml, ContextLoaderListener, DispatcherServlet, ...
  - An MVC app using JPA would need all of this
- *BUT: Much of this is predictable*
  - Spring Boot can do most of this setup for you



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## What is Spring Boot?

- An opinionated runtime for Spring Projects
- Supports different project types, like Web and Batch
- Handles most low-level, predictable setup for you
- It is not:
  - A code generator
  - An IDE plugin



See: [Spring Boot Reference](#)

<http://docs.spring.io/spring-boot/docs/current/reference/htmlsingle>



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## Topics in this Session

- **What is Spring Boot?**
  - Definition and Hello World example
- Spring Boot Explained
  - Dependency Management
  - Auto Configuration
  - Packaging
- Web Applications with Spring Boot
- Ease of Use Features



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## Opinionated Runtime?

- Spring Boot uses sensible defaults, “*opinions*”, mostly based on the classpath contents.
- For example
  - Sets up a JPA Entity Manager Factory if a JPA implementation is on the classpath.
  - Creates a default Spring MVC setup, if Spring MVC is on the classpath.
- Everything can be overridden easily
  - But most of the time not needed



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## Hello World example

- Just a few files to get a running Spring Web application

pom.xml

*Setup Spring Boot dependencies*

HelloController class

*Basic Spring MVC controller*

application.properties



hello.jsp

*View setup*

Application class

*Application launcher*



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## Hello World (1) – Maven descriptor

```
<parent>
  <groupId>org.springframework.boot</groupId> ← parent
  <artifactId>spring-boot-starter-parent</artifactId>
  <version>1.4.0.RELEASE</version>
</parent>
<dependencies>
  <dependency>
    <groupId>org.springframework.boot</groupId>
    <artifactId>spring-boot-starter-web</artifactId>
  </dependency>
</dependencies>
<build>
  <plugins>
    <plugin>
      <groupId>org.springframework.boot</groupId>
      <artifactId>spring-boot-maven-plugin</artifactId>
    </plugin>
  </plugins>
</build>
```

pom.xml

Spring MVC  
Embedded Tomcat  
Jackson...



Maven is just one option. You can also use Gradle or Ant/Ivy



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## Hello World (2) – Spring MVC controller

- A minimal controller to keep this example simple
  - Returns a JSP view-name

```
@Controller
public class HelloController {
  @RequestMapping("/")
  public String hello() {
    return "hello";
  }
}
```

Controller.java

Nothing to do, just return view name



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## Hello World (3) – Implement the View

```
<html>
  <head><title>Hello</title></head>
  <body>
    <p>Hello Spring Boot</p>
  </body>
</html>
```

/WEB-INF/views/hello.jsp

```
application.properties
```

```
spring.mvc.view.prefix=/WEB-INF/views
spring.mvc.view.suffix=.jsp
```

Configure an *InternalResourceViewResolver*



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## Hello World (4) – Application Class

- `@SpringBootApplication` annotation enables Spring Boot
  - Runs Tomcat *embedded*

```
@SpringBootApplication
public class Application {

  public static void main(String[] args) {
    SpringApplication.run(Application.class, args);
  }
}
```

application.java

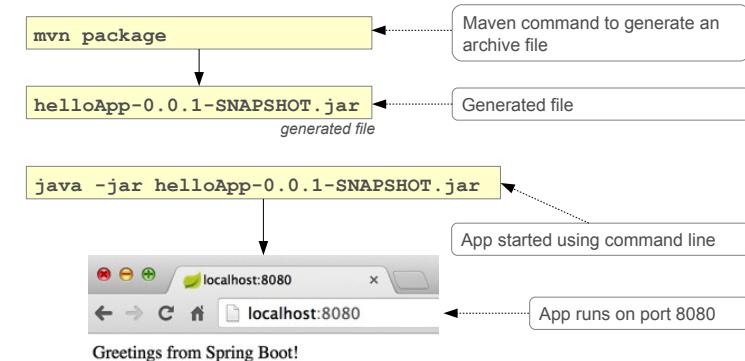


Main method will be used to run the packaged application from the command line – *old style!*



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## Putting it all together



## Deployment

- Our “Hello World” example bundles Tomcat inside the application
  - Runs as an executable **JAR**
- Spring Boot apps can also be deployed into an existing app server
  - As a familiar **WAR** file
  - PROs and CONs to be discussed later



## Topics in this Session

- What is Spring Boot?
  - Definition and Hello World example
- **Spring Boot Explained**
  - Dependency Management
  - Auto Configuration
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- Ease of Use Features



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## Spring Boot Needs Dependencies



- Auto-configuration works by analyzing the classpath
  - If you forget a dependency, Spring Boot can't configure it
  - A dependency management tool is recommended
    - Spring Boot parent and starters make it much easier
- Spring Boot works with Maven, Gradle, Ant/Ivy
  - Our content here will show Maven



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## Spring Boot Parent POM

- Parent POM defines key versions of dependencies and Maven plugins

```
<parent>
  <groupId>org.springframework.boot</groupId>
  <artifactId>spring-boot-starter-parent</artifactId>
  <version>1.4.0.RELEASE</version>
</parent>
```

Defines properties for dependencies, for example: \${spring.version} = 4.3



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## Core Spring “Starter” Dependencies

- Easy way to bring in multiple coordinated dependencies
  - Including “Transitive” Dependencies

```
<dependencies>
  <dependency>
    <groupId>org.springframework.boot</groupId>
    <artifactId>spring-boot-starter</artifactId>
  </dependency>
</dependencies>
```

Version not needed!  
Defined by parent.

Resolves ~ 16 JARs!

spring-boot-*jar	spring-core-*jar
spring-context-*jar	spring-aop-*jar
spring-beans-*jar	aopalliance-*jar
...	



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## Spring Web Dependencies

- Everything you need to develop a web application with Spring

```
<dependencies>
<dependency>
    <groupId>org.springframework.boot</groupId>
    <artifactId>spring-boot-starter-web</artifactId>
</dependency>
</dependencies>
```

Resolves  
spring-web-\*jar  
spring-webmvc-\*jar  
tomcat-\*jar  
jackson-databind-\*jar  
...



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## Test Dependencies

- Common test libraries

```
<dependencies>
<dependency>
    <groupId>org.springframework.boot</groupId>
    <artifactId>spring-boot-starter-test</artifactId>
</dependency>
</dependencies>
```

Resolves  
spring-test-\*jar  
junit-\*jar  
mockito-\*jar  
...



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## Available Starter POMs

- Not essential but *strongly* recommended
- Coordinated dependencies for common Java enterprise frameworks
  - Pick the starters you need in your project
- To name a few:
  - `spring-boot-starter-jdbc`
  - `spring-boot-starter-jpa`
  - `spring-boot-starter-batch`



See: [Spring Boot Reference, Starter POMs](http://docs.spring.io/spring-boot/docs/current/reference/htmlsingle/#using-boot-starter-poms)  
<http://docs.spring.io/spring-boot/docs/current/reference/htmlsingle/#using-boot-starter-poms>



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## Topics in this Session

- What is Spring Boot?
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## Spring Boot @EnableAutoConfiguration

- `@EnableAutoConfiguration` annotation on a Spring Java configuration class
  - Causes Spring Boot to automatically create beans it thinks you need
  - Usually based on classpath contents, can easily override

```
@Configuration  
@EnableAutoConfiguration  
public class AppConfig {  
    public static void main(String[] args) {  
        SpringApplication.run(AppConfig.class, args);  
    }  
}
```

Spring Boot class

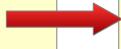


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## Shortcut @SpringBootApplication

- Very common to use `@EnableAutoConfiguration`, `@Configuration`, and `@ComponentScan`
  - `@ComponentScan`, with no arguments, scans the current package *and* its sub-packages

```
@Configuration  
@ComponentScan  
@EnableAutoConfiguration  
public class AppConfig {  
    ...  
}
```

 `@SpringBootApplication`

```
@SpringBootApplication  
public class AppConfig {  
    ...  
}
```

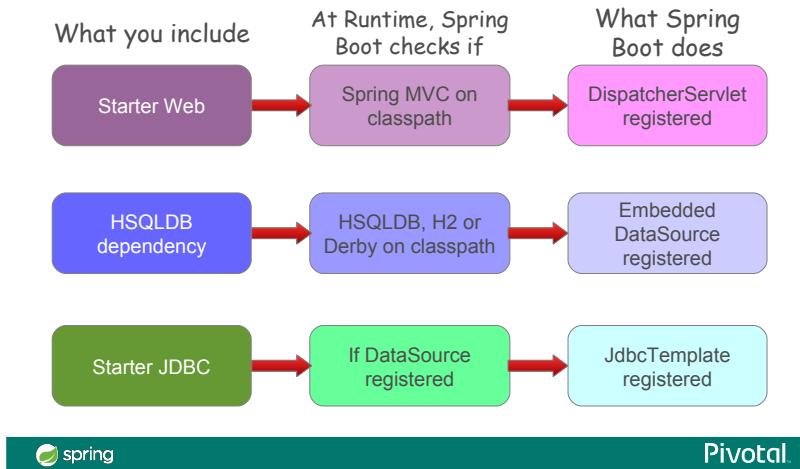


`@SpringBootApplication` was available from Spring Boot 1.2



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## Auto-configuration: Examples



## Topics in this Session

- What is Spring Boot?
  - Definition and Hello World example
- **Spring Boot Explained**
  - Dependency Management
  - Auto Configuration
  - **Packaging**
- Web Applications with Spring Boot
- Ease of Use Features

## Packaging

- Spring Boot creates a single archive
  - JAR (or WAR)
- Gradle and Maven plugins available
  - Generate an *executable* JAR  
`java -jar yourapp.jar`



## Maven Packaging

- Add Boot Maven plugin to pom.xml

```
<build>
  <plugins>
    <plugin>
      <groupId>org.springframework.boot</groupId>
      <artifactId>spring-boot-maven-plugin</artifactId>
    </plugin>
  </plugins>
</build>
```



## Packaging Result

- “`mvn package`” execution produces (in `target`)

```
22M yourapp-0.0.1-SNAPSHOT.jar  
5K yourapp-0.0.1-SNAPSHOT.jar.original
```

- `.jar.original` contains only your code (a traditional JAR file)
- `.jar` contains your code *and* all libs – executable
  - Notice that it is much bigger



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## Topics in this Session

- What is Spring Boot?
  - Definition and Hello World example
- Spring Boot Explained
- **Web Applications with Spring Boot**
  - Containerless Applications
  - Spring Boot inside of a Servlet Container
- Ease of Use Features



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## Spring Boot as a Runtime

- Spring Boot can startup an *embedded* web server
  - You can run a web application from a JAR file!
  - Tomcat included by Web Starter

```
<dependency>
  <groupId>org.springframework.boot</groupId>
  <artifactId>spring-boot-starter-web</artifactId>
</dependency>
```



Simpler for running and testing, may be preferred when deploying *Cloud Native* applications



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## Jetty Support

- Jetty can be used instead of Tomcat

```
<dependency>
  <groupId>org.springframework.boot</groupId>
  <artifactId>spring-boot-starter-web</artifactId>
  <exclusions>
    <exclusion>
      <groupId>org.springframework.boot</groupId>
      <artifactId>spring-boot-starter-tomcat</artifactId>
    </exclusion>
  </exclusions>
</dependency>
<dependency>
  <groupId>org.springframework.boot</groupId>
  <artifactId>spring-boot-starter-jetty</artifactId>
</dependency>
```

Excludes Tomcat

Adds Jetty

Jetty automatically detected and used!



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## JAR vs WAR?

- Why Run a Web Application Outside of a Container?
  - No separation of container config and app config
    - Depend on each other anyway (JNDI DS names, security config ...)
  - Projects usually know which container will be used
    - Why not just include it?
  - No special IDE support needed
    - Easier debugging and profiling, hot code replacement
  - Familiar model for non-Java developers
  - Recommended for Cloud Native applications
    - 12-Factor applications #7 (see <http://12factor.net>)



## Topics in this Session

- What is Spring Boot?
  - Definition and Hello World example
- Spring Boot Explained
- **Web Applications with Spring Boot**
  - Containerless Applications
  - **Spring Boot inside of a Servlet Container**
- Ease of Use Features



## Spring Boot in a Servlet Container

- Spring Boot can also run in any Servlet 3.x container
  - e.g. Tomcat 7+, Jetty 8+
- Only small changes required
  - Change artifact type to WAR (instead of JAR)
  - Extend `SpringBootServletInitializer`
  - Override configure method
- Still no `web.xml` required



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## Spring Boot WAR file

- Spring Boot produces hybrid WAR file
- Can still be executed with embedded Tomcat
  - using “`java -jar yourapp.war`”
- Traditional WAR file is produced as well
  - without embedded Tomcat
  - just drop it in your application server web app directory



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## Spring Boot in a Servlet Container

```
Sub-classes Spring's WebApplicationInitializer  
– called by the web container (Servlet 3.0)
```

```
@SpringBootApplication  
public class Application extends SpringBootServletInitializer {  
  
    protected SpringApplicationBuilder configure(  
        SpringApplicationBuilder application) {  
        return application.sources(Application.class);  
    }  
  
}
```



The above requires no *web.xml* file



## WAR Packaging Result

- “mvn package” execution produces:

```
22M  yourapp-0.0.1-SNAPSHOT.war  
20M  yourapp-0.0.1-SNAPSHOT.war.original
```

- .war.original is a traditional WAR file
- .war is a hybrid WAR file, additionally containing the embedded Tomcat



## Servlet Container and Containerless

- Can execute: `java -jar yourapp-0.0.1-SNAPSHOT.war`

```
@SpringBootApplication  
public class Application extends SpringBootServletInitializer {
```

```
    protected SpringApplicationBuilder configure(  
        SpringApplicationBuilder application) {  
        return application.sources(Application.class);  
    }
```

WAR support

```
    public static void main(String[] args) {  
        SpringApplication.run(Application.class, args);  
    }
```

Provides main  
method too

**Warning:** Embedded tomcat version must match version used with WAR



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## It's Your Choice



- There is no force to go containerless
  - Embedded container is just one feature of Spring Boot
- Traditional WAR also benefits a lot from Spring Boot
  - Automatic Spring MVC setup, including DispatcherServlet
  - Sensible defaults based on the classpath content
  - Embedded container can be used during development



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## Topics in this session

- What is Spring Boot?
  - Definition and Hello World example
- Spring Boot Explained
  - Dependency Management
  - Auto Configuration
  - Containerless Applications
  - Packaging
- Spring Boot inside of a Servlet Container
- **Ease of Use Features**



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## Externalized Properties – 1

*application.properties*

- Developers commonly externalize properties to files
  - Easily consumable via Spring PropertySource
  - But developers name / locate their files different ways
- Spring Boot looks for **application.properties** in well-known locations
  - You can put any properties you need in here and Boot will automatically find and load them
  - Available to `Environment` and `@Value` in usual way



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## Externalized Properties – 2

*application.properties*

- Spring Boot can be easily configured by setting any of its many, many properties
  - Set these in application.properties also
- Example: configure default **DataSource** bean

```
database.host=localhost  
database.user=admin
```

*application.properties*



See Appendix A of Spring Boot documentation:

<http://docs.spring.io/spring-boot/docs/current/reference/html/common-application-properties.html>



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## Externalized Properties – 3

YAML Alternative

- Spring Boot also supports YAML configuration
  - More concise, indented text format (similar to JSON)
  - By default it looks for **application.yml**
  - *Do not use tabs*

```
database:  
  host: localhost  
  user: admin
```

*application.yml*



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## Controlling Logging Level

- Boot can control the logging level
  - Just set it in `application.properties`
- Works with most logging frameworks
  - Java Util Logging, Logback, Log4J, Log4J2

```
logging.level.org.springframework=DEBUG  
logging.level.com.acme.your.code=INFO
```

*application.properties*



Try to stick to SLF4J in the application.

The *advanced* section covers how to change the logging framework



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## DataSource Configuration

- Use either `spring-boot-starter-jdbc` or `spring-boot-starter-data-jpa` and include a JDBC driver on classpath
- Declare properties

*application.properties*

```
spring.datasource.url=jdbc:mysql://localhost/test  
spring.datasource.username=dbuser  
spring.datasource.password=dbpass  
spring.datasource.driver-class-name=com.mysql.jdbc.Driver
```

- That's It!
  - Spring Boot will create a DataSource with properties set
  - Will even use a connection pool if the library is found on the classpath!



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## Web Application Convenience – 1



- Boot automatically configures
  - A `DispatcherServlet` & `ContextLoaderListener`
  - Spring MVC using same defaults as `@EnableWebMvc`
- **Plus many useful extra features:**
  - Static resources served from classpath
    - `/static`, `/public`, `/resources` or `/META-INF/resources`
  - Templates served from `/templates`
    - If Velocity, Freemarker, Thymeleaf, or Groovy on classpath
  - Provides default `/error` mapping
    - Easily overridden
  - Default `MessageSource` for I18N



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## Web Application Convenience – 2



- Spring Boot automatic web configuration
  - Because `spring-boot-starter-web*.jar`
    - Such as when `spring-boot-starter-web` is used
  - You did not specify `@EnableWebMvc`
- `@EnableWebMvc` in a Spring Boot application
  - Only sets up what `@EnableWebMvc` normally does
  - No Spring Boot web extras

**Bottom Line:** Most Spring Boot web applications do not specify `@EnableWebMvc`



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## Summary

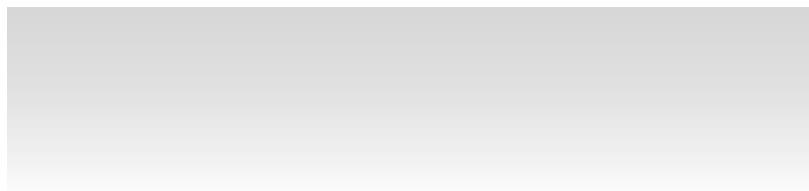
- Spring Boot speeds up Spring application development
- You always have full control and insight
- Nothing is generated
- No special runtime requirements
- No servlet container needed (if you want)
  - E.g. ideal for microservices

**Advanced Section:** More customization, Configuration using Properties or YAML files, Logging control, Boot-driven testing

*Spring-Boot Developer – 2 day in-depth Spring Boot workshop*



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## Lab

Simplification using Spring Boot



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# Spring Boot – Going Further

Going beyond default settings

Customization, Logging, YAML Properties, Testing



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## Topics in this Session

- **Understanding Auto-Configuration**
- Customizing Spring Boot
- More on Properties
- Fine-tuning Logging
- Using YAML for Configuration
- Testing



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## How Does Spring Boot Work?

- Extensive use of pre-written @Configuration classes
- Conditional on
  - The contents of the classpath
  - Properties you have set
  - Beans already defined
- @Profile is an example of conditional configuration
  - Spring Boot takes this idea to the next level



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## @Conditional Annotations

- Allow conditional bean creation
  - Only create if other beans exist (or don't exist)

```
@Bean  
@ConditionalOnBean(name={"dataSource"})  
public JdbcTemplate jdbcTemplate(DataSource dataSource) {  
    return new JdbcTemplate(dataSource);  
}
```

— Or by type: @ConditionalOnBean(type={DataSource.class})

- Many others:
  - @ConditionalOnClass, @ConditionalOnProperty, ...  
@ConditionalOnMissingBean, @ConditionalOnMissingClass



@Profile is a special case of @Conditional



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## What are AutoConfiguration Classes

- Pre-written Spring configurations
  - `org.springframework.boot.autoconfigure` package
  - See `spring-boot-autoconfigure` JAR file
    - Best place to check what they exactly do

```
@Configuration  
public class DataSourceAutoConfiguration  
    implements EnvironmentAware {  
    ...  
    @Conditional(...)  
    @ConditionalOnMissingBean(DataSource.class)  
    @Import(...)  
    protected static class EmbeddedConfiguration { ... }  
    ... }
```



Spring Boot defines many of these configurations. They activate in response to dependencies on the classpath



## Topics in this Session

- Understanding Auto-Configuration
- **Customizing Spring Boot**
- More on Properties
- Fine-tuning Logging
- Using YAML for Configuration
- Testing



# Controlling What Spring Boot does

- There are several options
  - Set some of Spring Boot's properties
  - Define certain beans yourself so Spring Boot won't
  - Explicitly disable some auto-configuration
  - Changing dependencies



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## 1. Using Properties

- Spring Boot looks for **application.properties** in these locations (in this order):
  - `/config` sub-directory of the working directory
  - The working directory
  - `config` package in the classpath
  - classpath root
- Creates a *PropertySource* based on these files
- Many, many configuration properties available



See: [Spring Boot Reference, Appendix A. Common Application Properties](http://docs.spring.io/spring-boot/docs/current/reference/htmlsingle/#common-application-properties)  
<http://docs.spring.io/spring-boot/docs/current/reference/htmlsingle/#common-application-properties>



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## 2. Replacing Generated Beans

- Normally beans you declare *explicitly* disable any auto-created ones.
  - Example: Your DataSource stops Spring Boot creating a default DataSource
  - Bean name often not important
  - Works with XML, Component Scanning and/or Java Config

```
@Bean  
public DataSource dataSource() {  
    return new EmbeddedDatabaseBuilder()  
        . setName("RewardsDb").build();  
}
```



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## 3. Selectively Disabling Auto Configuration

- Can disable some AutoConfiguration classes
  - If they don't suit your needs
- Use the `@EnableAutoConfiguration` annotation
  - List the auto-configuration classes to exclude in the “exclude” attribute

```
@EnableAutoConfiguration(exclude=DataSourceAutoConfiguration.class)  
public class ApplicationConfiguration {  
    ...  
}
```



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## 4a. Overriding Dependency Versions

- Spring Boot POMs preselect the versions of frameworks
  - Ensures the versions of all frameworks are consistent
  - Avoids “*dependency hell*”
- Should I override the version of a given framework?
  - Ideally no, it makes your life more complicated
- But there are good reasons to override it sometimes
  - A bug in the given version
  - Company policies



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## 4b. Overriding Dependency Versions

- Set the appropriate Maven property in your pom.xml

```
<properties>
    <spring.version>4.2.0.RELEASE</spring.version>
</properties>
```

- Check this POM to know all the properties names
  - <https://github.com/spring-projects/spring-boot/blob/master/spring-boot-dependencies/pom.xml>



This only works if you *inherit* from the starter. You need to redefine the artifact if you directly import the dependency



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## Configuration Example: DataSource (1)

- A common example of how to control or override Spring Boot's default configuration
- Typical customizations
  - Use the predefined properties
  - Change the underlying data source connection pool implementation
  - Define your own DataSource bean (shown earlier)



## *Example:* DataSource Configuration (2)

- Common properties configurable from properties file

```
spring.datasource.url=          # Connection settings
spring.datasource.username=
spring.datasource.password=
spring.datasource.driver-class-name=

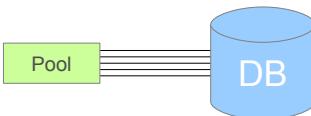
spring.datasource.schema=        # SQL scripts to execute
spring.datasource.data=

spring.datasource.initial-size=   # Connection pool settings
spring.datasource.max-active=
spring.datasource.max-idle=
spring.datasource.min-idle=
```



## *Example: DataSource Configuration (3)*

- Spring Boot creates a pooled DataSource by default
  - If a known pool dependency is available
    - *spring-boot-starter-jdbc* or *spring-boot-starter-jpa* starters pull in *tomcat-jdbc* connection pool by default
  - Alternatives: Tomcat, HikariCP, Commons DBCP 1 & 2
    - Simply use relevant dependency



## *Example: Web Container Configuration*

- Many settings accessible from the configuration file

```
server.port=9000
server.address=192.168.1.20
server.session-timeout=1800
server.context-path=/rewards
server.servlet-path=/admin
```

- Also available
  - SSL (keystore, truststore for client authentication)
  - Tomcat specifics (access log, compression, etc)



## Topics in this Session

- Understanding Auto-Configuration
- Customizing Spring Boot
- **More on Properties**
- Fine-tuning Logging
- Using YAML for Configuration
- Testing



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### Overriding Properties

Applies to Spring

or Spring Boot

- Order of evaluation of the properties (non-exhaustive)
  - Command line arguments
  - Java system properties
  - OS environment variables
  - Property file(s) – including `application.properties`
- Can access any of them using `@Value` in the usual way
- *Recommendation:*
  - Use Property files to define defaults
  - Override *externally* using one of the other 3 options



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## Renaming `application.properties`

- You can override the name of this file
  - Example: to use `myserver.properties`

```
public static void main(String[] args) {  
    System.setProperty("spring.config.name", "myserver");  
    SpringApplication.run(Application.class, args);  
}
```

*Application.java*

Note: myserver **not**  
`myserver.properties`



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## Relaxed Property Binding

- No need for exact match between desired properties and names
- Intuitive mapping between java-style properties and environment variables
  - `path` equivalent to `PATH`
  - `java.home` equivalent to `JAVA_HOME`
- Easy overriding of property without changing the name!

```
@Configuration  
class AppConfig {  
  
    @Value("${java.home}")  
    String javaInstallDir;  
  
    ...  
}
```



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## The Problem with Property Placeholders

- Using property placeholders is sometimes cumbersome
  - Many properties, prefix has to be repeated

```
@Configuration  
public class RewardsClientConfiguration {  
  
    @Value("${rewards.client.host}") String host;  
    @Value("${rewards.client.port}") int port;  
    @Value("${rewards.client.logdir}") String logdir;  
    @Value("${rewards.client.timeout}") int timeout;  
  
    ...  
}
```



## Use @ConfigurationProperties

- Add `@ConfigurationProperties` to *dedicated* container bean
  - Will hold the externalized properties
  - Avoids repeating the prefix
  - Data-members automatically set from corresponding properties

```
@Component  
@ConfigurationProperties(prefix="rewards.client")  
public class ConnectionSettings {  
  
    private String host;  
    private int port;  
    private String logdir;  
    private int timeout;  
    ... // getters/setters  
}
```

rewards.client.host=192.168.1.42  
rewards.client.port=8080  
rewards.client.logdir=/logs  
rewards.client.timeout=2000  
application.properties



## Use `@EnableConfigurationProperties`

- `@EnableConfigurationProperties` on configuration class
  - Specify and auto-inject the container bean

```
@Configuration  
@EnableConfigurationProperties(ConnectionSettings.class)  
public class RewardsClientConfiguration {  
    // Spring initialized this automatically  
    @Autowired ConnectionSettings connectionSettings;  
  
    @Bean public RewardClient rewardClient() {  
        return new RewardClient(  
            connectionSettings.getHost(),  
            connectionSettings.getPort(), ...  
        );  
    }  
}
```



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## Topics in this Session

- Understanding Auto-Configuration
- Customizing Spring Boot
- More on Properties
- **Fine-tuning Logging**
- Using YAML for Configuration
- Testing



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## Logging frameworks

- Spring Boot includes by default
  - SLF4J: logging facade
  - Logback: SLF4J implementation
- Best practice: stick to this in your application
  - Use the SLF4J abstraction the application code
- Other logging frameworks are supported
  - Java Util Logging, Log4J, Log4J2



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## Using another logging framework

```
<dependency>
    <groupId>org.springframework.boot</groupId>
    <artifactId>spring-boot-starter-websocket</artifactId>
    <exclusions>
        <exclusion>
            <groupId>ch.qos.logback</groupId>
            <artifactId>logback-classic</artifactId>
        </exclusion>
    </exclusions>
</dependency>

<dependency>
    <groupId>org.slf4j</groupId>
    <artifactId>slf4j-log4j12</artifactId>
</dependency>
```

The diagram illustrates the configuration of a dependency in a build file. It shows two main sections: one for excluding the Logback library and one for including the Log4J library.

- Excludes Logback:** An annotation points to the exclusion of the Logback library (group ID ch.qos.logback, artifact ID logback-classic) from the spring-boot-starter-websocket dependency.
- Includes Log4J:** An annotation points to the addition of the Log4J library (group ID org.slf4j, artifact ID slf4j-log4j12) as a dependency.



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## Logging Output

- Spring Boot logs by default to the console
- Can also log to rotating files
  - Specify file OR path in application.properties

```
# Use only one of the following properties  
  
# absolute or relative file to the current directory  
logging.file=rewards.log  
  
# will write to a spring.log file  
logging.path=/var/log/rewards
```



Spring Boot can also configure logging by using the appropriate configuration file of the underlying logging framework.



## Topics in this Session

- Understanding Auto-Configuration
- Customizing Spring Boot
- More on Properties
- Fine-tuning Logging
- **Using YAML for Configuration**
- Testing



## What is YAML?

- *Yaml Ain't a Markup Language*
  - Recursive acronym
- Created in 2001
- Alternative to .properties files
  - Allows hierarchical configuration
- Java parser for YAML is called SnakeYAML
  - Must be in the classpath
  - Provided by spring-boot-starters



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## YAML for Properties

- Spring Boot support YAML for Properties
  - An alternative to properties files



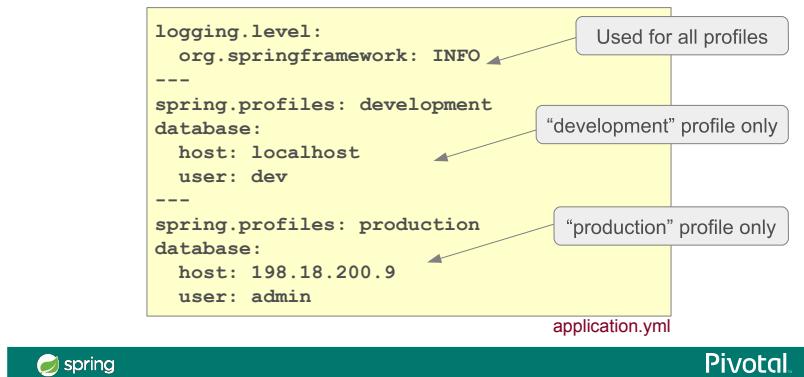
- YAML is convenient for hierarchical configuration data
  - Spring Boot properties are organized in groups
  - Examples: server, database, etc



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## Multiple Profiles Inside a Single YAML File

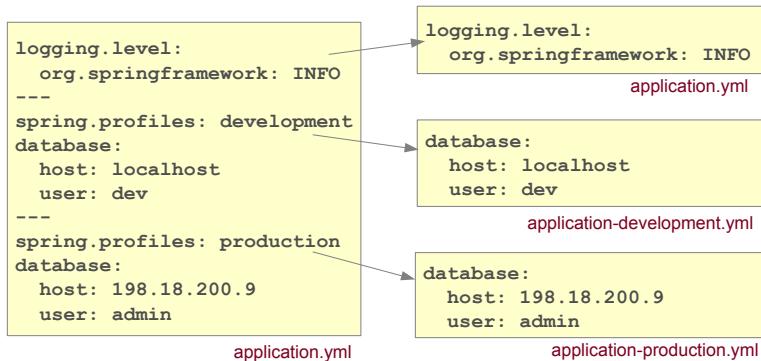
- YAML file can contain configuration for multiple profiles
  - '---' implies a separation between profiles



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## Multiple Profiles Inside Multiple Files



Alternatively `application-development.properties` and `application-production.properties` can be used in same way

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## Topics in this Session

- Understanding Auto-Configuration
- Customizing Spring Boot
- More on Properties
- Fine-tuning Logging
- Using YAML for Configuration
- **Testing**



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### Testing: `@SpringBootTest`

```
Alias for SpringJUnit4ClassRunner
@RunWith(SpringRunner.  
@SpringBootTest(classes=TransferApplication.class)
public final class TransferServiceTests {
    @Autowired
    private TransferService transferService;

    @Test
    public void successfulTransfer() {
        TransferConfirmation conf = transferService.transfer(...);
        ...
    }
}
```

`@SpringBootApplication`

```
public class TransferApplication {
    public static void main(String[] args) {
        SpringApplication.run(TransferApplication.class, args);
    }
}
```

A callout box points from the `@RunWith` annotation to the `TransferServiceTests` class, with the text: "Alias for `SpringJUnit4ClassRunner`". Another callout box points from the `@SpringBootTest` annotation to the same class, with the text: "Sets up *same* configuration for the tests that the application would use".



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# Web Application Testing

Can use *with or without* Spring Boot

- Spring Unit test with `@WebAppConfiguration`
  - Creates a `WebApplicationContext`
  - Can test code that uses web features
    - `ServletContext`, `Session` and `Request` bean scopes
  - Configures the location of resources
    - Defaults to `src/main/webapp`
      - Override using annotation's value attribute
    - For classpath resources use `classpath:` prefix

```
@RunWith(SpringRunner.class)
@WebAppConfiguration
public final class TransferServiceTests { ... }
```



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## Summary

- Spring Boot takes care of boilerplate configuration
  - Auto-configuration can be overridden/disabled
  - Frameworks versions can be overridden too
- Spring Boot enhances Spring configuration externalization mechanisms
  - Properties/YAML files
  - Easier to override using env/Java system variables



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# Spring Security

## Web Application Security

Addressing Common Security Requirements



## Topics in this Session

- **High-Level Security Overview**
- Motivations of Spring Security
- Spring Security in a Web Environment
- Configuring Web Authentication
- Using Spring Security's Tag Libraries
- Method security
- Advanced security: working with filters



# Security Concepts

- Principal
  - User, device or system that performs an action
- Authentication
  - Establishing that a principal's credentials are valid
- Authorization
  - Deciding if a principal is allowed to perform an action
- Secured item
  - Resource that is being secured



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## Authentication

- There are many authentication mechanisms
  - e.g. basic, digest, form, X.509
- There are many storage options for credential and authority information
  - e.g. Database, LDAP, in-memory (development)



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## Authorization

- Authorization depends on authentication
  - Before deciding if a user can perform an action, user identity must be established
- The decision process is often based on roles
  - ADMIN can cancel orders
  - MEMBER can place orders
  - GUEST can browse the catalog



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## Topics in this Session

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See: **Spring Security Reference**

<http://docs.spring.io/spring-security/site/docs/current/reference/htmlsingle/>



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## Motivations - I

- Spring Security is portable across containers
  - Secured archive (WAR, EAR) can be deployed as-is
  - Also runs in standalone environments
  - Uses Spring for configuration
- Separation of Concerns
  - Business logic is decoupled from security concerns
  - Authentication and Authorization are decoupled
    - Changes to the authentication process have *no impact* on authorization



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## Motivations: II

- Flexibility
  - Supports all common authentication mechanisms
    - Basic, Form, X.509, Cookies, Single-Sign-On, etc.
  - Configurable storage options for user details (credentials and authorities)
    - RDBMS, LDAP, custom DAOs, properties file, etc.
- Extensible
  - All the following can be customized
    - How a principal is defined
    - How authorization decisions are made
    - Where security constraints are stored



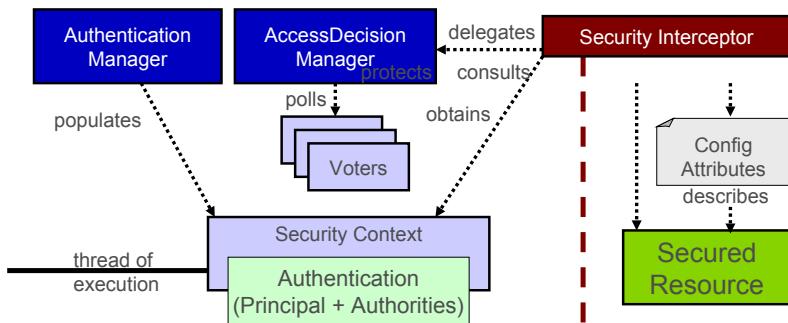
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## Consistency of Approach

- The goal of authentication is *always the same regardless* of the mechanism
  - Establish a security context with the authenticated principal's information
  - Out-of-the-box this works for web applications
- The *process of authorization is always the same* regardless of resource type
  - Consult the attributes of the secured resource
  - Obtain principal information from security context
  - Grant or deny access



## Spring Security – the Big Picture



## Topics in this Session

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## Setup the Filter Chain

- Implementation is a *chain* of Spring configured filters
  - Requires a `DelegatingFilterProxy` called `springSecurityFilterChain`
- Use *one* of these options
  - Spring Boot does it automatically
  - Use `@EnableWebSecurity`
    - See next slide
    - For total control, subclass Spring Security's web-initializer
      - `AbstractSecurityWebApplicationInitializer`
  - Declare as a `<filter>` in `web.xml` in usual way



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## Configuration in the Application Context

- Java Configuration (XML also available)
  - Extend `WebSecurityConfigurerAdapter` for more control

```
@Configuration  
@EnableWebSecurity  
public class SecurityConfig extends WebSecurityConfigurerAdapter {  
  
    @Override  
    protected void configure(HttpSecurity http) throws Exception {  
        }  
    }  
  
    @Autowired  
    public void configureGlobal(AuthenticationManagerBuilder auth) throws Exception {  
        }  
    }  
}
```

Diagram annotations:

- A callout box labeled "Web-specific security settings" points to the first method block (`protected void configure(HttpSecurity http) throws Exception { ... }`).
- A callout box labeled "General security settings (authentication manager, ...)." points to the second method block (`public void configureGlobal(AuthenticationManagerBuilder auth) throws Exception { ... }`).



## authorizeRequests()

- Adds specific authorization requirements to URLs
- Evaluated in the order listed
  - first match is used, put specific matches first

```
protected void configure(HttpSecurity http) throws Exception {  
    http  
        .authorizeRequests()  
            .antMatchers("/css/**", "/images/**", "/javascript/**").permitAll()  
            .antMatchers("/accounts/edit**").hasRole("ADMIN")  
            .antMatchers("/accounts/account**").hasAnyRole("USER", "ADMIN")  
            .antMatchers("/accounts/**").authenticated()  
            .antMatchers("/customers/checkout**").fullyAuthenticated()  
            .antMatchers("/customers/**").anonymous();  
}
```



## Specifying login and logout

```
protected void configure(HttpSecurity http) throws Exception {  
    http  
        .authorizeRequests()  
            .antMatchers("/aaa*").hasRole("ADMIN")  
            .and() // method chaining!  
  
        .formLogin() // setup form-based authentication  
            .loginPage("/login.jsp") // URL to use when login is needed  
            .permitAll() // any user can access  
            .and() // method chaining!  
  
        .logout() // configure logout  
            .permitAll(); // any user can access  
}
```



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## An Example Login Page

URL that indicates an authentication request.  
Default: POST against URL used to display the page.

```
<c:url var='loginUrl' value='/login.jsp' />  
<form:form action="${loginUrl}" method="POST">  
    <input type="text" name="username"/>  
    <br/>  
    <input type="password" name="password"/>  
    <br/>  
    <input type="submit" name="submit" value="LOGIN"/>  
</form:form>
```

The expected keys for generation of an authentication request token

*login-example.jsp*



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## Topics in this Session

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- Advanced security: working with filters



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## Configure Authentication

- DAO Authentication provider is default
  - Expects a *UserDetailsService* implementation to provide credentials and authorities
    - Built-in: In-memory (properties), JDBC (database), LDAP
    - Custom
- Or define your own Authentication provider
  - *Example:* to get pre-authenticated user details when using single sign-on
    - CAS, TAM, SiteMinder ...
  - See online examples



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## Authentication Provider

- Use a *UserDetailsManagerConfigurer*
  - Three built in options:
    - LDAP, JDBC, in-memory (for quick testing)
  - Or use your own *UserDetailsService* implementation

```
@Autowired  
public void configureGlobal(AuthenticationManagerBuilder auth) throws Exception {  
    auth  
        .inMemoryAuthentication()  
            .withUser("hugie").password("hugie").roles("GENERAL").and()  
            .withUser("dewey").password("dewey").roles("ADMIN").and()  
            .withUser("louie").password("louie").roles("SUPPORT");  
}
```

Not web-specific

Adds a *UserDetailsManagerConfigurer*

login      password      Supported roles

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## Sourcing Users from a Database

- Configuration:

```
@Autowired DataSource dataSource;  
  
public void configureGlobal(AuthenticationManagerBuilder auth) throws Exception {  
    auth.jdbcAuthentication().dataSource(dataSource);  
}
```

Can customize queries using methods:  
`usersByUsernameQuery()`  
`authoritiesByUsernameQuery()`  
`groupAuthoritiesByUsername()`

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## Sourcing Users from a Database

Queries RDBMS for users and their authorities

- Provides default queries
  - `SELECT username, password, enabled FROM users WHERE username = ?`
  - `SELECT username, authority FROM authorities WHERE username = ?`
- Groups also supported
  - `groups, group_members, groupAuthorities` tables
  - See online documentation for details
- Advantage
  - Can modify user info while system is running



## Password Encoding

- Can encode passwords using a hash
  - sha, md5, bcrypt, ...

```
auth.jdbcAuthentication()  
.dataSource(dataSource)  
.passwordEncoder(new StandardPasswordEncoder());
```

SHA-256 encoding

- Secure passwords using a well-known string
  - Known as a 'salt', makes brute force attacks harder

```
auth.jdbcAuthentication()  
.dataSource(dataSource)  
.passwordEncoder(new StandardPasswordEncoder("sodium-chloride"));
```

encoding with salt



## Other Authentication Options

- Implement a custom UserDetailsService
  - Delegate to an existing User repository or DAO
- LDAP
- X.509 Certificates
- JAAS Login Module
- Single-Sign-On
  - OAuth, SAML
  - SiteMinder, Kerberos
  - JA-SIG Central Authentication Service

Authorization is *not* affected by changes to Authentication!



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## @Profile with Security Configuration

```
public class SecurityBaseConfig extends WebSecurityConfigurerAdapter {  
    protected void configure(HttpSecurity http) throws Exception {  
        http.authorizeRequests().antMatchers("/resources/**")  
    }  
}
```

```
@Configuration  
@EnableWebSecurity  
@Profile("development")
```

*Use in-memory provider*

```
public class SecurityDevConfig extends SecurityBaseConfig {  
    @Autowired  
    public void configureGlobal(AuthenticationManagerBuilder auth) throws Exception {  
        auth.inMemoryAuthentication()  
            .withUser("huglie").password("huglie").roles("GENERAL");  
    }  
}
```



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## @Profile with Security Configuration

```
public class SecurityBaseConfig extends WebSecurityConfigurerAdapter {  
    protected void configure(HttpSecurity http) throws Exception {  
        http.authorizeRequests().antMatchers("/resources/**").permitAll();  
    }  
}  
  
@Configuration  
@EnableWebSecurity  
@Profile("production") Use database provider  
public class SecurityProdConfig extends SecurityBaseConfig {  
    @Autowired  
    public void configureGlobal(AuthenticationManagerBuilder auth) throws Exception {  
        auth.jdbcAuthentication().dataSource(dataSource);  
    }  
}
```



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## Topics in this Session

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## Tag library declaration

- The Spring Security tag library is declared as follows

```
<%@ taglib prefix="security"
    uri="http://www.springframework.org/security/tags" %>
```

available since Spring Security 2.0

jsp

- Facelet tags for JSF are also available
  - You need to define and install them manually
  - See “Using the Spring Security Facelets Tag Library” in the Spring Webflow documentation
  - Principal available in SpEL: `#{}principal.username`
- Equivalent functionality for other View technologies



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## Spring Security’s Tag Library

- Display properties of the Authentication object

```
You are logged in as:
<security:authentication property="principal.username"/>
```

jsp

- Hide sections of output based on role
  - Not recommended, roles in JSP page (see next slide)

```
<security:authorize access="hasRole('ADMIN')">
    TOP-SECRET INFORMATION
    Click <a href="/admin/deleteAll">HERE</a> to delete all records.
</security:authorize>
```

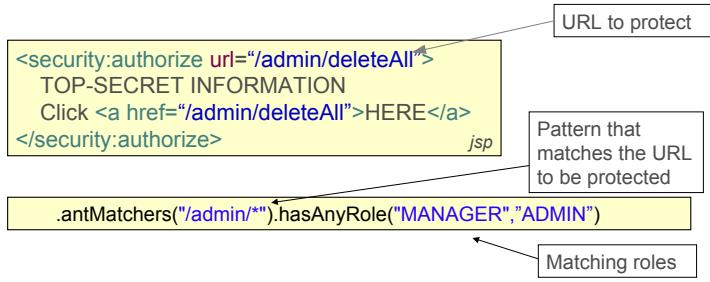
jsp



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## Authorization in JSP based on intercept-url

- Role declaration can be centralized in Spring config files



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## Topics in this Session

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- Method security**
- Advanced security: working with filters



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## Method Security

- Spring Security uses AOP for security at the method level
  - annotations based on Spring annotations or JSR-250 annotations
  - Java configuration to activate detection of annotations
- Typically secure your services
  - Do not access repositories directly, bypasses security (and transactions)



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## Method Security - JSR-250

- JSR-250 annotations should be enabled

```
@EnableGlobalMethodSecurity(jsr250Enabled = true)
```

```
import javax.annotation.security.RolesAllowed;

public class ItemManager {
    @RolesAllowed({"ROLE_MEMBER", "ROLE_USER"})
    public Item findItem(long itemNumber) {
        ...
    }
}
```



Only supports **role-based** security – hence the name



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## Method Security - @Secured

- Secured annotation should be enabled

```
@EnableGlobalMethodSecurity(securedEnabled=true)
```

```
import org.springframework.security.annotation.Secured;  
  
public class ItemManager {  
    @Secured("IS_AUTHENTICATED_FULLY")  
    public Item findItem(long itemNumber) {  
        ...  
    }  
    @Secured("ROLE_MEMBER")  
    @Secured({"ROLE_MEMBER", "ROLE_USER"})
```



Spring 2.0 syntax, so *not* limited to roles. SpEL *not* supported.

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## Method Security with SpEL

- Use Pre/Post annotations for SpEL

```
@EnableGlobalMethodSecurity(prePostEnabled=true)
```

```
import org.springframework.security.annotation.PreAuthorize;  
  
public class ItemManager {  
    @PreAuthorize("hasRole('MEMBER')")  
    public Item findItem(long itemNumber) {  
        ...  
    }  
}
```

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## Topics in this Session

- High-Level Security Overview
- Motivations of Spring Security
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- **Advanced security: working with filters**



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## Spring Security in a Web Environment

- *SpringSecurityFilterChain*
  - Spring Boot does this automatically
  - Or declare in servlet configuration
- This single proxy filter delegates to a chain of Spring-managed filters
  - Drive authentication
  - Enforce authorization
  - Manage logout
  - Maintain SecurityContext in HttpSession
  - *and more*



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## *Example: Configuration in web.xml*

- Define the single proxy filter
  - `springSecurityFilterChain` is a mandatory name
  - Refers to an existing Spring bean with same name

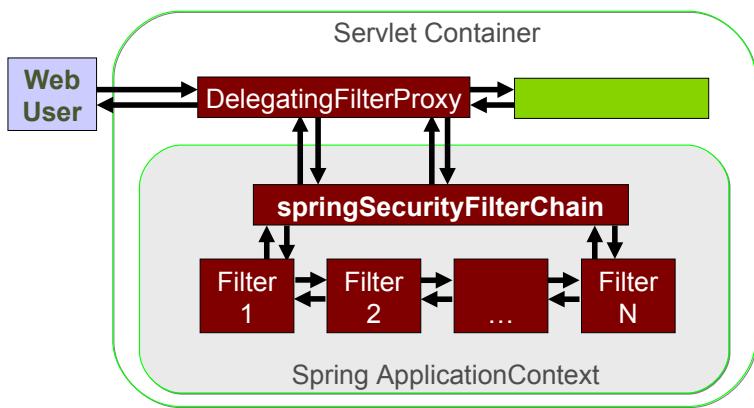
```
<filter>                                         web.xml
  <filter-name>springSecurityFilterChain</filter-name>
  <filter-class>
    org.springframework.web.filter.DelegatingFilterProxy
  </filter-class>
</filter>

<filter-mapping>
  <filter-name>springSecurityFilterChain</filter-name>
  <url-pattern>/*</url-pattern>
</filter-mapping>
```



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## Web Security Filter Configuration



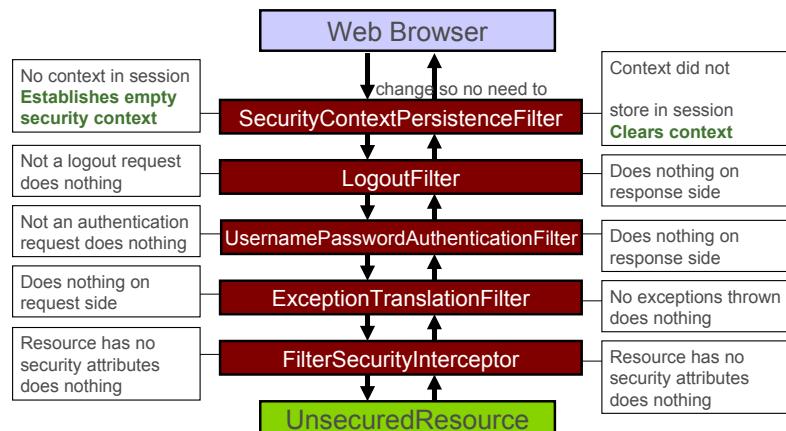
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## The Filter Chain

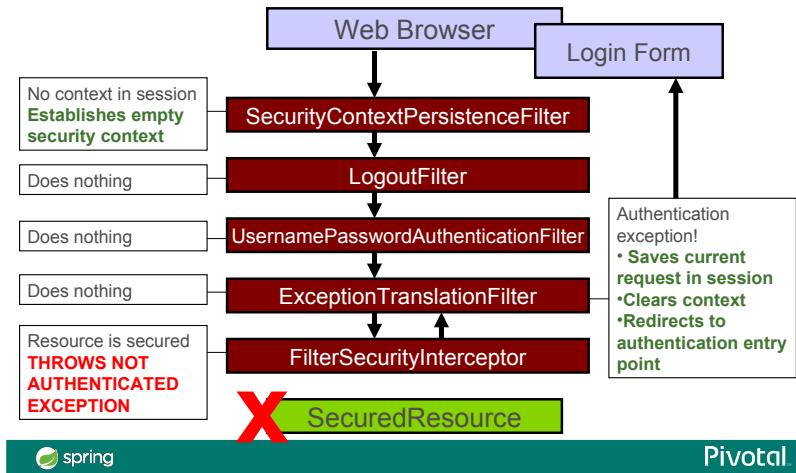
- With ACEGI Security 1.x
  - Filters were manually configured as individual <bean> elements
  - Led to verbose and error-prone XML
- Spring Security 2.x, 3.x, 4.x
  - Filters are initialized with correct values by default
  - Manual configuration is not required **unless you want to customize Spring Security's behavior**
  - It is still important to understand how they work underneath



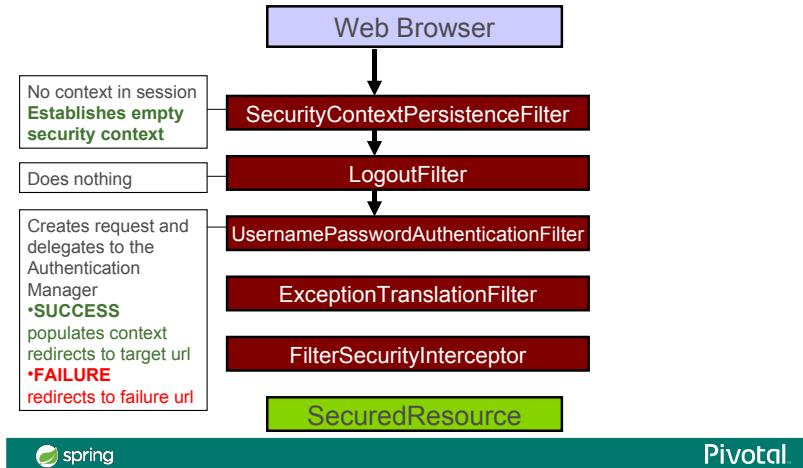
### Access Unsecured Resource Prior to Login



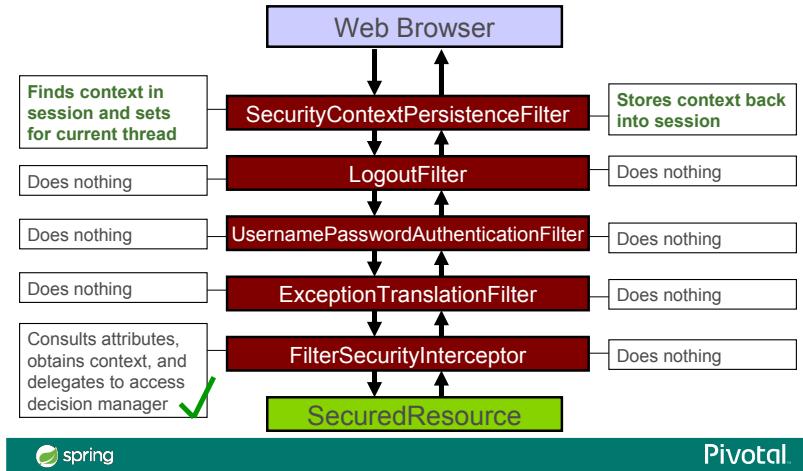
## Access Secured Resource Prior to Login



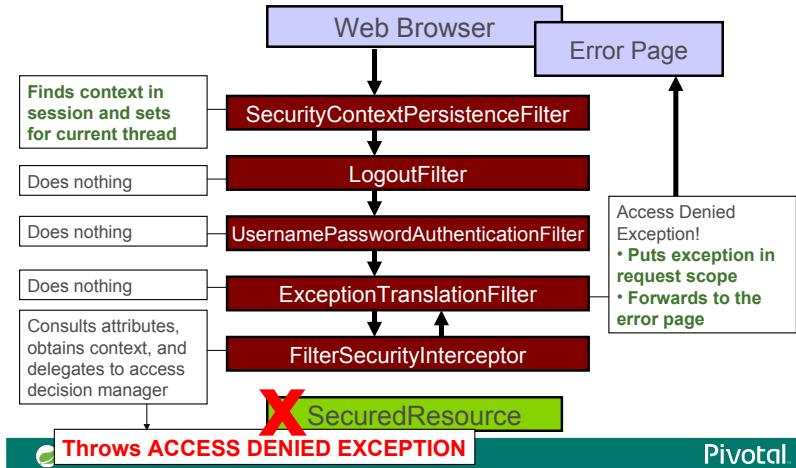
## Submit Login Request



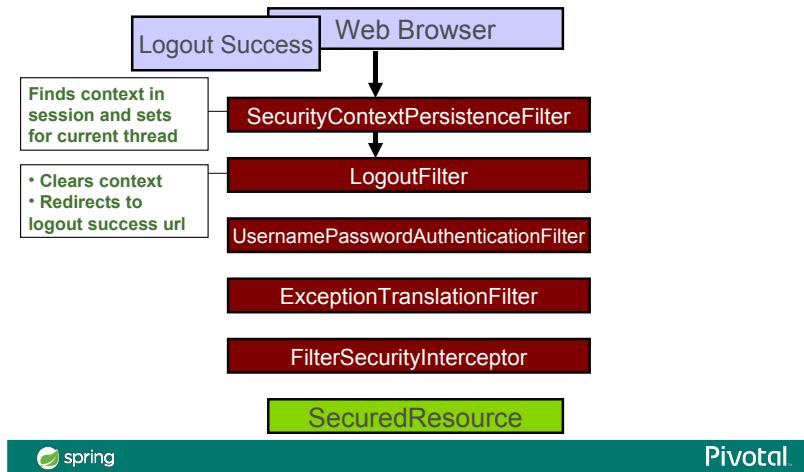
## Access Resource With Required Role



## Access Resource Without Required Role



## Submit Logout Request



## The Filter Chain: Summary

#	Filter Name	Main Purpose
1	SecurityContext IntegrationFilter	Establishes SecurityContext and maintains between HTTP requests <i>formerly: HttpSessionContextIntegrationFilter</i>
2	LogoutFilter	Clears SecurityContextHolder when logout requested
3	UsernamePassword AuthenticationFilter	Puts Authentication into the SecurityContext on login request <i>formerly: AuthenticationProcessingFilter</i>
4	Exception TranslationFilter	Converts SpringSecurity exceptions into HTTP response or redirect
5	FilterSecurity Interceptor	Authorizes web requests based on config attributes and authorities

## Custom Filter Chain

- Filter can be **added** to the chain
  - Before or after existing filter

```
http.addFilterAfter ( myFilter, UsernamePasswordAuthenticationFilter.class );  
...  
@Bean  
public Filter myFilter() { return new MySpecialFilter(); }
```

- Filter on the stack may be **replaced** by a custom filter
  - Replacement must extend the filter being replaced.

```
http.addFilter ( myFilter );  
...  
@Bean  
public Filter myFilter() {  
    return new MySpecialFilter();  
}
```

```
public class MySpecialFilter  
    extends UsernamePasswordAuthenticationFilter {}
```



## Summary



- Spring Security
  - Secure URLs using a chain of Servlet filters
  - And/or methods on Spring beans using AOP proxies
- Out-of-the-box setup usually sufficient – you define:
  - URL and/or method restrictions
  - How to login (typically using an HTML form)
  - Supports in-memory, database, LDAP credentials (and more)
  - Password encryption using familiar hashing techniques
  - Support for security tags in JSP views



# Lab

Applying Spring Security to a Web Application



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# Practical REST Web Services

Using Spring MVC to build RESTful Web Services

Extending Spring MVC to handle REST

## Topics in this Session



- REST introduction
- Spring MVC support for RESTful applications
  - Request/Response Processing
  - Accessing Request/Response Data
  - Putting it all together
- RESTful Clients with the RestTemplate
- Advanced Topics

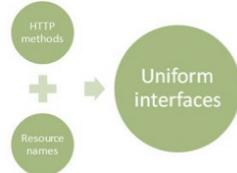
## REST Introduction

- Web apps not just usable by browser clients
  - Programmatic clients can also connect via HTTP
  - Such as: mobile applications, AJAX enabled web-pages
- REST is an *architectural style* that describes best practices to expose web services over HTTP
  - REpresentational S<sub>T</sub>ate T<sub>R</sub>ansfer, term by Roy Fielding
  - HTTP as *application* protocol, not just transport
  - Emphasizes scalability
  - *Not* a framework or specification



## REST Principles (1)

- Expose *resources* through URIs
  - Model nouns, not verbs
  - <http://springbank.io/banking/accounts/123456789>
- Resources support limited set of operations
  - GET, PUT, POST, DELETE in case of HTTP
  - All have well-defined semantics
- Example: update an order
  - PUT to </orders/123>
  - don't POST to </order/edit?id=123>



## REST Principles (2)

- Clients can request particular representation
  - Resources can support multiple representations
  - HTML, XML, JSON, ...
- Representations can link to other resources
  - Allows for extensions and discovery, like with web sites
- Hypermedia As The Engine of Application State
  - *HATEOAS*: Probably the world's worst acronym!
  - RESTful responses contain the links you need – just like HTML pages do



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## REST Principles (3)

- Stateless architecture
  - No HttpSession usage
  - GETs can be cached on URL
  - Requires clients to keep track of state
  - Part of what makes it scalable
  - Looser coupling between client and server
- HTTP headers and status codes communicate result to clients
  - All well-defined in HTTP Specification



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## Why REST?

- Benefits of REST
  - Every platform/language supports HTTP
    - Unlike for example SOAP + WS-\* specs
  - Easy to support many different clients
    - Scripts, Browsers, Applications
  - Scalability
  - Support for redirect, caching, different representations, resource identification, ...
  - Support for XML, but also other formats
    - JSON and Atom are popular choices



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## REST and Java: JAX-RS



### JAX-RS

- JAX-RS is a Java EE 6 standard for building RESTful applications
  - Focuses on programmatic clients, not browsers
- Various implementations
  - Jersey (RI), RESTEasy, Restlet, CXF
    - All implementations provide Spring support
- Good option for full REST support using a standard
- No support for building clients in standard
  - Although some implementations do offer it



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- Spring-MVC provides REST support as well
  - Since version 3.0
  - Using familiar and consistent programming model
  - Spring MVC does not implement JAX-RS
- Single web-application for everything
  - Traditional web-site: HTML, browsers
  - Programmatic client support (RESTful web applications, HTTP-based web services)
- RestTemplate for building programmatic clients in Java



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## Topics in this Session

- REST introduction
- **Spring MVC support for RESTful applications**
  - Request/Response Processing
  - Accessing Request/Response Data
  - Putting it all together
- RESTful Clients with the RestTemplate
- Advanced Topics



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## Spring-MVC and REST

- Will now extend Spring MVC to support REST
  - Map requests based on HTTP method
  - Define response status
  - Message Converters
  - Access request and response body data
  - Build valid Location URIs



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## Topics in this Session

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## Request Mapping Based on HTTP Method

- Can map HTTP requests based on method
  - Allows same URL to be mapped to multiple methods
  - Often used for form-based controllers (GET & POST)
  - Essential to support RESTful resource URLs
    - incl. PUT and DELETE

```
@RequestMapping(path="/orders", method=RequestMethod.GET)
public void listOrders( ... ) {
    // find all Orders and add them to the model
}

@RequestMapping(path="/orders", method=RequestMethod.POST)
public void createOrder( ... ) {
    // process the order data from the request
}
```



## Simpler Mapping Annotations

Spring 4.3

- Alternative handler mapping shortcuts
  - `@RequestMapping(path="/accounts")`
  - Or `@GetMapping("/accounts")`;
- Exist for each HTTP method
  - `@GetMapping`
  - `@PostMapping`
  - `@PutMapping`
  - `@DeleteMapping`
  - `@PatchMapping`



# HTTP Status Code Support



- Web apps just use a handful of status codes
  - Success: 200 OK
  - Redirect: 30x for Redirects
  - Client Error: 404 Not Found
  - Server Error: 500 (such as unhandled Exceptions)
- RESTful applications use many additional codes
  - Created Successfully: 201
  - HTTP method not supported: 405
  - Cannot generate response body requested: 406
  - Request body not supported: 415



For a full list: [https://en.wikipedia.org/wiki/List\\_of\\_HTTP\\_status\\_codes](https://en.wikipedia.org/wiki/List_of_HTTP_status_codes)



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## @ResponseStatus

place at class-level,  
applies to *all* methods

Spring 4.3 – Can

- To return a status code *other* than 200
  - Use HttpStatus enumerator
- **Note:** @ResponseStatus on **void** methods
  - No longer want to return a view name - *no View at all!*
  - Method returns a response with empty body (*no-content*)

```
@RequestMapping(path="/orders/{id}",
                 method=RequestMethod.PUT)
@ResponseStatus(HttpStatus.NO_CONTENT) // 204
public void updateOrder(HttpServletRequest request) {
    Order order = getOrder(request);      // Extract from request
    orderService.updateOrder(order);
}
```



Can also set error response codes – see Advanced section



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# Accessing Request/Response Data



- *The Problem*
  - HTTP `GET` needs to return data in response body
  - HTTP `POST` and `PUT` receive data in request body
  - Typically XML or JSON
  - Want to deal in Java objects
  - Want to avoid converting between formats manually
- *The Solution*
  - Use *Marshaling* via dedicated `message-converters`
  - Annotate incoming data with `@RequestBody`
  - Annotate outgoing data with `@ResponseBody`



## HttpMessageConverter

- Converts HTTP request/response body data
  - XML (using JAXP Source, JAXB2 mapped object, Jackson-Dataformat-XML\*)
  - Jackson JSON\*, GSON\*Feed data\* such as Atom/RSS
  - Google protocol buffers \*
  - Form-based data
  - `Byte[], String, BufferedImage`
- **Must** enable otherwise no convertors defined at all!
  - Automatic with Spring Boot
  - `@EnableWebMvc` OR `<mvc:annotation-driven/>`
  - Or define explicitly (allows you to register extra convertors)
    - Using `WebMvcConfigurer` OR `<mvc:/>`

\* Requires 3rd party  
libraries on classpath



## @RequestBody

- To use converters for incoming request data
  - Correct converter chosen automatically
    - Based on content type of request
  - `updatedOrder` could be mapped from XML (with JAXB2) or from JSON (with Jackson)
    - Annotate Order class to help JAXB/Jackson work

```
@RequestMapping(path="/orders/{id}", method=RequestMethod.PUT)
@ResponseStatus(HttpStatus.NO_CONTENT) // 204
public void updateOrder(@RequestBody Order updatedOrder,
                        @PathVariable("id") long id) {
    // process updated order data and return empty response
    orderManager.updateOrder(id, updatedOrder);
}
```



## @ResponseBody

- Use converters for response data by annotating return data with `@ResponseBody`
- Converter handles rendering a response
  - Again, no ViewResolver and View involved any more!

```
@RequestMapping(path="/orders/{id}", method=RequestMethod.GET)
@ResponseStatus(HttpStatus.OK) // 200
public @ResponseBody Order getOrder(@PathVariable("id") long id) {
    // Order class is annotated with JAXB2's @XmlRootElement
    Order order= orderService.findOrderById(id);
    // results in XML response containing marshalled order:
    return order;
}
```



## What Return Format? Accept Header

```
@RequestMapping(path="/orders/{id}", method=RequestMethod.GET)
@ResponseStatus(HttpStatus.OK) // 200
public @ResponseBody Order getOrder(@PathVariable("id") long id) {
    return orderService.findOrderById(id);
}
```

```
GET /store/orders/123
Host: shop.spring.io
Accept: application/xml, ...
...
```

```
HTTP/1.1 200 OK
Date: ...
Content-Length: 1456
Content-Type: application/xml
<order id="123">
...
</order>
```

```
GET /store/orders/123
Host: shop.spring.io
Accept: application/json, ...
...
```

```
HTTP/1.1 200 OK
Date: ...
Content-Length: 756
Content-Type: application/json
{
    "order": {"id": 123,
              "items": [ ... ], ... }
}
```



## @RestController Simplification

Spring 4.0

```
@Controller
public class OrderController {
    @RequestMapping(path="/orders/{id}", method=RequestMethod.GET)
    public @ResponseBody Order getOrder(@PathVariable("id") long id) {
        return orderService.findOrderById(id);
    }
}

@RestController
public class OrderController {
    @RequestMapping(path="/orders/{id}", method=RequestMethod.GET)
    public Order getOrder(@PathVariable("id") long id) {
        return orderService.findOrderById(id);
    }
}
...
```

No need for @ResponseBody on GET methods



## Topics in this Session

- REST introduction
- Spring MVC support for RESTful applications
  - Request/Response Processing
  - **Accessing Request/Response Data**
  - Putting it all together
- RESTful Clients with the RestTemplate
- Advanced Topics



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## Accessing Request/Response Data

- Can explicitly inject `HttpServletRequest` (and `HttpServletResponse`)
  - But makes Controller methods hard to test
  - Consider Spring's `MockHttp...` classes
- Spring can *automatically* inject part of the request
  - `@RequestParam`, `@PathVariable`, `Principal`, `Locale`, `@Value`, `@RequestHeader`,
  - `@RequestBody`, `@ResponseBody`
- To perform REST we may also use
  - `HttpEntity`, `ResponseEntity`



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## HttpEntity and ResponseEntity

- To build responses explicitly
  - Set headers, control content returned
  - Use `HttpEntity` or `ResponseEntity`

```
// Want to return a String as the response-body
HttpHeaders headers = new HttpHeaders();
headers.setContentType(MediaType.TEXT_PLAIN);
HttpEntity<String> entity =
    new HttpEntity<String>("Hello Spring", headers);

// ResponseEntity (since Spring 4.1) supports a "fluent" API
ResponseEntity<String> response =
    ResponseEntity.ok()
        .contentType(MediaType.TEXT_PLAIN)
        .body("Hello Spring");
```



## Setting Response Data

- Can use `HttpEntity` to generate a Response
  - Avoids use of `HttpHeaders` (easier to test)

```
@RequestMapping(path="/orders/{id}", method=RequestMethod.GET)
public HttpEntity<Order> getOrder(@RequestParam("id") long id) {
    String order = orderService.find(id);

    HttpHeaders responseHeaders = new HttpHeaders();
    responseHeaders.set("Content-Type", "text/xml");

    return new HttpEntity<Order>(order, responseHeaders);
}
```

Response  
body type

Response  
body



## Building URIs



- An HTTP POST typically returns location of newly created resource in the response header
- How to create a URI?
  - **UriComponentsBuilder**
    - Allows explicit creation of URI
    - *But* uses hard-coded URLs
  - **ServletUriComponentsBuilder**
    - Provides access to the URL that invoked the current controller method



## Building URIs: UriComponentsBuilder

- Support for building URIs from templated strings
  - Escapes illegal `%20` for a space as

```
String templateUrl =  
    "http://store.spring.io/orders/{orderId}/items/{itemId}";  
  
URI location = UriComponentsBuilder.  
    fromHttpUrl(templateUrl).  
    buildAndExpand("123456","item A").  
    toUri();  
  
return ResponseEntity.created(location).build();  
  
// http://store.spring.io/orders/123456/items/item%20A
```

Use of hard-coded URL *not recommended*

Convenient way to build POST response



## ServletUriComponentsBuilder

- Use in a Controller method
  - Avoids hard-coding URL

```
// Must be in a Controller method
// Example: POST /orders/{id}

URI location = ServletUriComponentsBuilder
    .fromCurrentRequestUri() ←
    .path("items/{itemId}")
    .buildAndExpand("item A")
    .toUri(); ;

return ResponseEntity.created(location).build();

// http://.../items/item%20A
```

Framework puts request URL in current thread – which builder can access



## Lesson Roadmap

- REST and Java
- Spring MVC support for RESTful applications
  - Request/Response Processing
  - Accessing Request/Response Data
  - **Putting it all together**
- RESTful Clients with the RestTemplate
- Advanced Topics



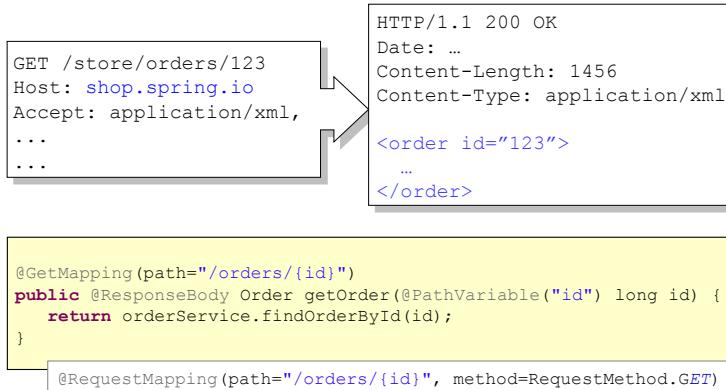
## Putting it all Together



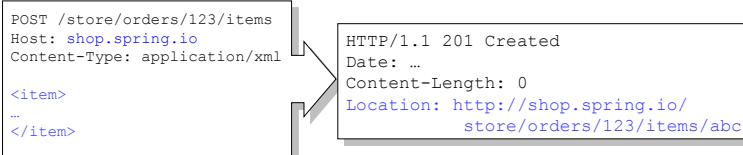
- We have covered many new concepts
  - `@ResponseStatus`
  - HTTP Message Converters
  - `@RequestBody`, `@ResponseBody`
  - `HttpEntity`, `ResponseEntity`
  - `UriComponentsBuilder`
- Let's see some typical Controller implementations for each of `GET`, `POST`, `PUT` and `DELETE`
  - Useful reference when you are writing a new Controller
    - *And for the lab!*



## Retrieving a Representation



## Creating a new Resource: POST (1)



- The most complicated to implement
  - “201 Created” requires `Location` header for new resource
  - Will need `ServletUriComponentsBuilder` and `ResponseEntity`



## Creating a new Resource: POST (2)

```
@PostMapping(path="/orders/{id}/items")
@ResponseStatus(HttpStatus.CREATED) // 201
public ResponseEntity<Void>
createItem(@PathVariable("id") long id, @RequestBody Item newItem) {
    // Add the new item to the order
    orderService.findOrderById(id).addItem(newItem);

    // Build the location URI of the new item
    URI location = ServletUriComponentsBuilder
        .fromCurrentRequestUri()
        .path("{itemId}")
        .buildAndExpand(newItem.getId())
        .toUri();

    return ResponseEntity.created(location).build();
}
```

`@RequestMapping(path="/orders/...", method=RequestMethod.POST)`

Assume added id to item



## Updating existing Resource: **PUT**

```
PUT /store/orders/123/items/abc  
Host: shop.spring.io  
Content-Type: application/xml  
  
<item>  
...  
</item>
```

```
HTTP/1.1 204 No Content  
Date: ...  
Content-Length: 0
```

```
@PutMapping(path="/orders/{orderId}/items/{itemId}")  
@ResponseStatus(HttpStatus.NO_CONTENT) // 204  
public void updateItem(@PathVariable("orderId") long orderId,  
                      @PathVariable("itemId") String itemId,  
                      @RequestBody Item item) {  
    orderService.findOrderById(orderId).updateItem(itemId, item);  
}  
  
@RequestMapping(path="/orders/...", method=RequestMethod.PUT)
```



## Deleting a Resource:

```
DELETE /store/orders/123/items/abc  
Host: shop.spring.io  
...
```

```
HTTP/1.1 204 No Content  
Date: ...  
Content-Length: 0
```

```
@DeleteMapping(path="/orders/{orderId}/items/{itemId}")  
@ResponseStatus(HttpStatus.NO_CONTENT) // 204  
public void deleteItem(@PathVariable("orderId") long orderId,  
                      @PathVariable("itemId") String itemId) {  
    orderService.findOrderById(orderId).deleteItem(itemId);  
}  
  
@RequestMapping(path="/orders/...", method=RequestMethod.DELETE)
```



## Topics in this Session

- REST introduction
- Spring MVC support for RESTful applications
- **RESTful Clients with the RestTemplate**
- Advanced Topics



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## RestTemplate

- Provides access to RESTful services
  - Supports all the HTTP methods

HTTP Method	RestTemplate Method
<b>DELETE</b>	delete(String url, Object... urlVariables)
<b>GET</b>	getForObject(String url, Class<T> responseType, Object... urlVariables)
<b>HEAD</b>	headForHeaders(String url, Object... urlVariables)
<b>OPTIONS</b>	optionsForAllow(String url, Object... urlVariables)
<b>POST</b>	postForLocation(String url, Object request, Object... urlVariables) postForObject(String url, Object request, Class<T> responseType, Object... urlVariables)
<b>PUT</b>	put(String url, Object request, Object... urlVariables)



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## Defining a RestTemplate

- Just call constructor in your code
  - Setups default *HttpMessageConverters* internally
    - Same as on the server, depending on classpath

```
RestTemplate template = new RestTemplate();
```



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## RestTemplate Usage Examples

```
RestTemplate template = new RestTemplate();
String uri = "http://example.com/store/orders/{id}/items";
// GET all order items for an existing order with ID 1:
OrderItem[] items =
    template.getForObject(uri, OrderItem[].class, "1");
// POST to create a new item
OrderItem item = // create item object
URI itemLocation = template.postForLocation(uri, item, "1");
// PUT to update the item
item.setAmount(2);
template.put(itemLocation, item);
// DELETE to remove that item again
template.delete(itemLocation);
```

{id} = 1

{id} = 1



Also supports *HttpEntity*, for example to set HTTP request headers



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## Summary



- REST is an architectural style that can be applied to HTTP-based applications
  - Useful for supporting diverse clients and building highly scalable systems
- Spring-MVC adds REST support using a familiar programming model (but *without Views*)
  - `@ResponseStatus`, `@RequestBody`, `@ResponseBody`
  - `HttpEntity`, `ResponseEntity`, `UriComponentsBuilder`
  - HTTP Message Converters
- Clients use *RestTemplate* to access RESTful servers



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## Lab

Restful applications with Spring MVC

**Coming Up:** More on Spring MVC REST  
Introduction to Spring HATEOAS



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## Topics in this Session

- REST introduction
- Spring MVC support for RESTful applications
- RESTful clients with the RestTemplate
- **Advanced Topics**
  - More on Spring REST
  - Spring HATEOAS



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## @ResponseStatus & Exceptions

- Can also annotate exception classes with this
  - Given status code used when an unhandled exception is thrown from *any* controller method

```
@ResponseStatus(HttpStatus.NOT_FOUND) // 404
public class OrderNotFoundException extends RuntimeException {
    ...
}

@GetMapping(value="/orders/{id}")
public String showOrder(@PathVariable("id") long id, Model model) {
    Order order = orderService.findOrderById(id);
    if (order == null) throw new OrderNotFoundException(id);
    model.addAttribute(order);
    return "orderDetail";
}
```

**NOTE:** this is *not* a RESTful method,  
it returns a view-name.



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## @ExceptionHandler

- For existing exceptions you cannot annotate, use `@ExceptionHandler` method on controller
  - Method signature similar to request handling method
  - Also supports `@ResponseStatus`

```
@ResponseStatus(HttpStatus.CONFLICT) // 409
@ExceptionHandler({DataIntegrityViolationException.class})
public void conflict() {
    // could add the exception, response, etc. as method params
}
```



Spring MVC offers several ways to handle exceptions, for more details  
see <http://spring.io/blog/2013/11/01/exception-handling-in-spring-mvc>



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## Mixing Views and Annotations - 1

- REST methods do not return HTML, PDF, ...
  - No message converter
  - Views better for presentation-rich representations
- How to distinguish between representations?
  - Or a RESTful POST from a HTML form submission
- Use *produces* and *consumes* attributes

```
@GetMapping(value="/orders/{id}", produces = {"application/json"})
@PostMapping(value="/orders/{id}", consumes = {"application/json"})
```



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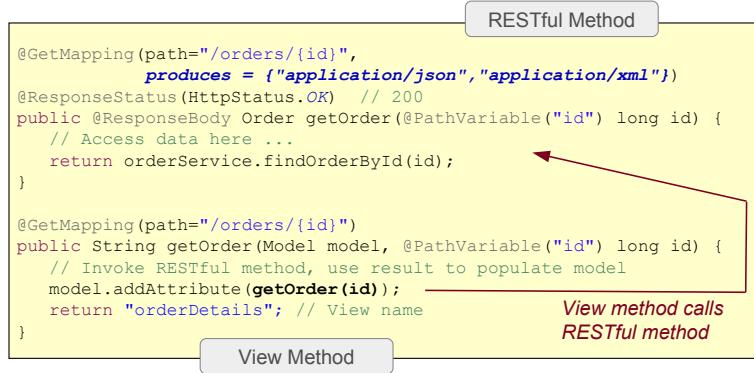
## Mixing Views and Annotations – 2

- Need two methods on controller for same URL
  - One uses a converter, the other a View
  - Identify using *produces* attribute
- Recommendation
  - Mark RESTful method with *produces*
    - To avoid returning XML to normal browser request
  - Call RESTful method from View method
    - Implement all data-access logic *once* in RESTful method



## Mixing Views and Annotations - 3

- Recommendation



## HttpMethodFilter

- HTML forms do not support PUT or DELETE
  - Not even in HTML 5
- So use a POST
  - Put PUT or DELETE in a *hidden* form field
- Deploy a special filter to intercept the message
  - Restores the HTTP method you wanted to send
  - Appear to Spring MVC as a PUT or a DELETE



See *HttpMethodFilter* in online documentation



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## Topics in this Session

- REST introduction
- Spring MVC support for RESTful applications
  - Request/Response Processing
  - Using MessageConverters
  - Putting it all together
- RESTful clients with the RestTemplate
- **Advanced Topics**
  - More on Spring REST
  - **Spring HATEOAS**



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## HATEOAS - Concepts

- REST clients need *no* prior knowledge about how to interact with a particular application/server
  - SOAP web-services need a WSDL
  - SOA processes require a fixed interface defined using interface description language (IDL)
- Clients interact entirely through hypermedia
  - Provided dynamically by application servers
- Serves to *decouple* client and server
  - Allows the server to evolve functionality independently
  - Unique compared to other architectures



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## HATEOAS Account Example

```
<account>
  <account-number>12345</account-number>
  <balance currency="usd">100.00</balance>
  <link rel="self" href="/account/12345"
  <link rel="deposit" href="/account/12345/deposits" />
  <link rel="withdraw" href="/account/12345/withdrawls" />
  <link rel="transfer" href="/account/12345/transfers" />
  <link rel="close" href="/account/12345/close" />
</account>
```

```
<account>
  <account-number>12345</account-number>
  <balance currency="usd">-25.00</balance>
  <link rel="self" href="/account/12345"
  <link rel="deposit" href="/account/12345/deposits" />
</account>
```

Spring HATEOAS

provides an API for generating these links in MVC Controller responses

Note: links change as state changes



There is no standard for links yet. This example uses the link style from the Hypertext Application Language (HAL), one possible representation



From: <http://restcookbook.com/Basics/hateoas/>

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## Managing Links

- Use **Link** class
  - Holds an href and a rel (relationship)
  - Self implies the current resource
  - Link builder derives URL from Controller mappings

```
// A link can be built with a relationship name
// Use withSelfRel() for a self link
Link link = ControllerLinkBuilder.linkTo(AccountController.class)
    .slash(accountId).slash("transfer").withRel("transfer");

link.getRel();      // => transfer
link.getHref();    // => http://.../account/12345/transfer
```



## Converting to a Resource

- Wrap return value of REST method in Resource
  - Converted by **@ResponseBody** to XML/JSON with links
    - Only HAL supported currently

```
@Controller
@EnableHypermediaSupport(type=HypermediaType.HAL)
public class OrderController {

    @GetMapping(value="/orders/{id}")
    public @ResponseBody Resource<Order>
        getOrder(@PathVariable("id") long id) {
        Links[] = ...; // Some links (see previous slide)
        return new Resource<Order>
            (orderService.findOrderById(id), links);
    }
}
```



## Spring HATEOAS



- Spring Data sub-project for REST
  - For generating links in RESTful responses
  - Supports ATOM (newsfeed XML) and HAL (Hypertext Application Language) links
  - Many other features besides examples shown here
- For more information see
  - <http://projects.spring.io/spring-hateoas/>
  - <http://spring.io/guides/gs/rest-hateoas/>

# Microservices with Spring

Building Cloud Native Applications

Introduction to Spring Cloud

## Roadmap



- **What is Microservices Architecture?**
- Pros and Cons of Microservices
- Managing Microservices
- Tooling: Spring, Spring Cloud, Netflix
- Building a Simple Microservice System



## Introduction

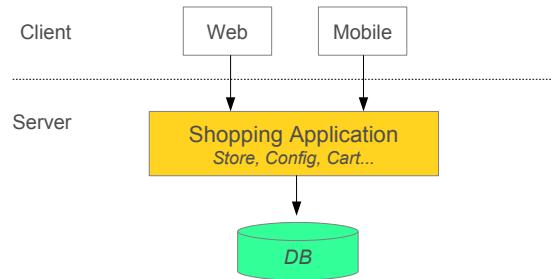
- “Microservices” is not a new word
  - Term coined in 2005 by Dr Peter Rodgers
    - Then called “*micro web services*” and based on SOAP
  - Term started to become popular since 2010
    - Proposed by a group of architects in Venice during 2011
    - Used in 2012 in a [presentation from James Lewis](#)
    - Meanwhile Adrian Cockcroft (Netflix), was describing this approach as “fine grained SOA”

<http://martinfowler.com/articles/microservices.html>



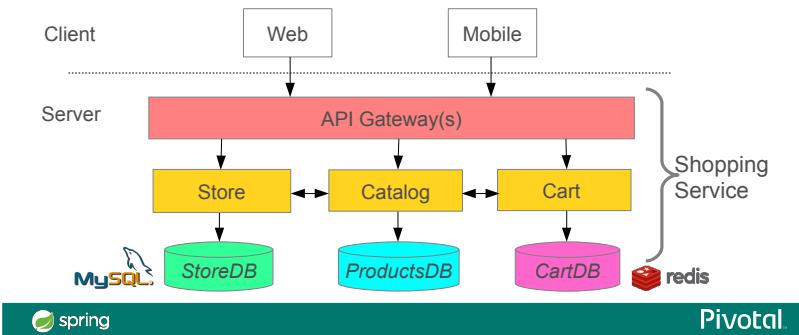
## Without Microservices

- Using a “monolith” architecture
  - All-in-One application



## With Microservices

- Main application has been divided in a set of sub-applications
  - Called microservices



## Roadmap



- What is Microservices Architecture?
- **Pros and Cons of Microservices**
- Managing Microservices
- Tooling: Spring, Spring Cloud, Netflix
- Building a Simple Microservice System



## Core Spring Concepts Applied to Application Architecture



- Spring enables *separation-of-concerns*
  - *Loose Coupling*: Effect of change is isolated
  - *Tight Cohesion*: Code performs a single well-defined task
- Microservices exhibit the same strengths
  - *Loose Coupling*
    - Applications are built from collaborating services (processes)
    - Can change independently so long as protocols unchanged
  - *Tight Cohesion*
    - An application (service) that deals with a *single* view of data
    - Also known as “Bounded Contexts” (*Domain-Driven Design*)



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## Microservice Benefits



- Smaller code base is easy to maintain
- Easy to scale
  - Scale individual component
- Technology diversity
  - Mix libraries, frameworks, data storage, languages
- Fault Isolation
  - Component failure should not bring whole system down
- Better support for smaller, parallel teams
- Independent deployment



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## Microservice Challenges



- Difficult to achieve strong consistency across services
  - ACID transactions *do not* span multiple processes
  - Eventual consistency, Compensating transactions
- Distributed system
  - Harder to debug/trace
  - Greater need for end-to-end testing
  - Expect, test for and handle the failure of any process
  - More components to maintain: redundancy, HA
- Typically requires “cultural” change (*Dev Ops*)
  - How applications are developed and deployed
  - Devs and Ops working *together*, even on same team!



## Use a Platform to Support This



- Platforms\* like *Pivotal Cloud Foundry* aid deployment
  - Easily run, scale, monitor and recover multiple processes
  - Run up a complete dev system for end-to-end testing
- Support for
  - Continuous Deployment
  - Rolling upgrades of new versions of code
    - Also termed: Blue/Green or Canary rollout
    - Quick rollback in case of defects
  - Running multiple versions of same service at same time
    - Makes migration easier for downstream projects

\*Platform as a Service (PaaS)



# Roadmap



- What is Microservices Architecture?
- Pros and Cons of Microservices
- **Developing Microservices**
- Tooling: Spring, Spring Cloud, Netflix
- Building a Simple Microservice System



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## Microservice Infrastructure

- Multiple processes working together
- Issues that now arise:

- How do they find each other? Service Discovery
- How do we decide which instance to use? Client-side Load Balancing
- What happens if a microservice is not responding Fault Tolerance
- How do we control access? OAuth, ...
- How do they communicate? Messaging REST
- To just name a few!

We cover these today



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## Roadmap



- What is Microservices Architecture?
- Pros and Cons of Microservices
- Managing Microservices
- **Tooling: Spring, Spring Cloud, Netflix**
- Building a Simple Microservice System



## Microservices made-easy by Spring

- Setup a new service using Spring Boot
- Expose resources via a RestController
- Consume remote services using RestTemplate
- Will leverage capabilities from *Spring Cloud Project*



# What is Spring Cloud?



- Building blocks for Cloud and Microservice applications
  - Microservices Infrastructure
    - Provides useful services such as Service Discovery, Configuration Server and Monitoring
    - Several based on other Open Source projects
      - Netflix OSS, HashiCorp's Consul, ...
  - Platform Support
    - Access platform-specific information and services
      - Available for Cloud Foundry, AWS and Heroku
  - Uses Spring Boot style starters
    - Requires Spring Boot to work

HASHICORP

NETFLIX | OSS



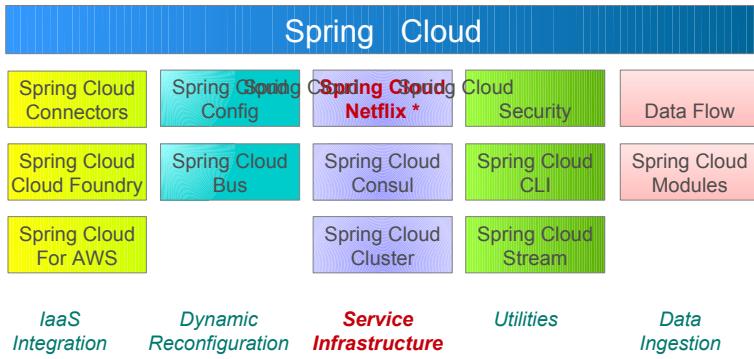
<http://projects.spring.io/spring-cloud>

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\* Today we only have time

to look at the Netflix project

## Spring Cloud Ecosystem



Spring Cloud is at <http://projects.spring.io/spring-cloud/>



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# Spring Cloud Usage Examples

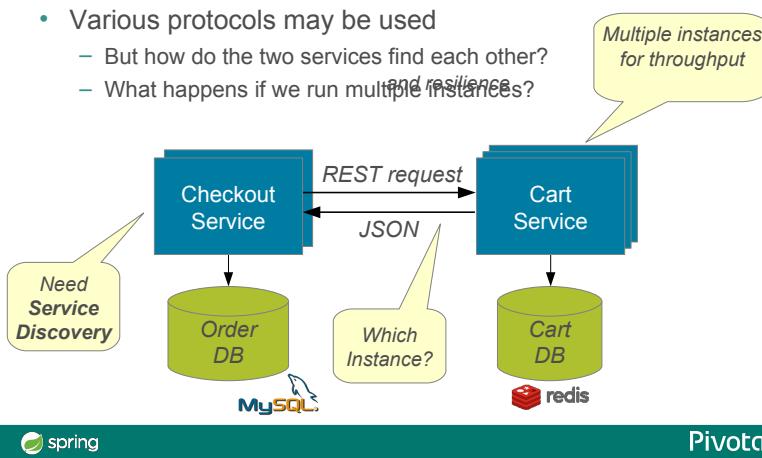


- There are *many* use-cases supported by Spring Cloud
  - Cloud Integration, Dynamic Reconfiguration, Service Discovery, Security, Data Ingestion
- Today we concentrate on *microservices* support
  - **Service Discovery**
    - How do the services find each other?
  - **Client-side Load Balancing**
    - Each service typically deployed as multiple instances
      - For fault-tolerance and load-sharing
    - How do we decide which service *instance* to use?

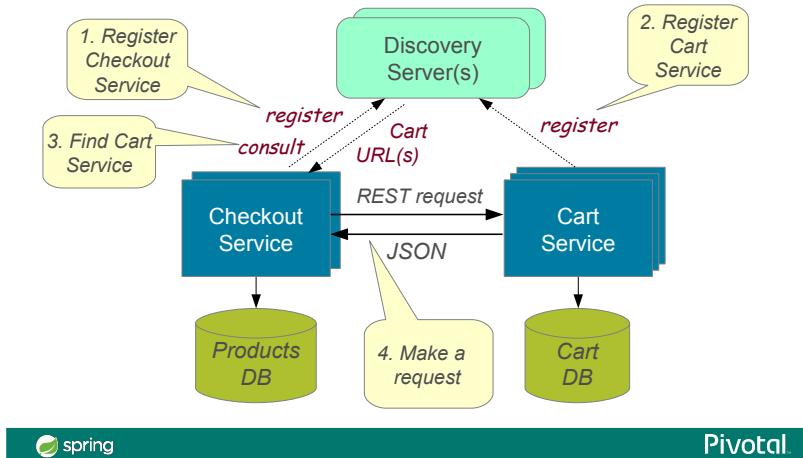


## Why We Need Service Discovery – 1

- Various protocols may be used
  - But how do the two services find each other?
  - What happens if we run multiple instances?



## Why We Need Service Discovery – 2



## Implementing Service Discovery

- Spring Cloud supports several
  - We will use Eureka
    - Created by Netflix
  - Consul.io is another option
    - Hashicorp project (inventors of Vagrant)
- Spring Cloud makes it easy
  - To utilize either of those servers
  - Hiding their internal complexity

NETFLIX | OSS

HASHICORP



See also: <http://spring.io/blog/2015/07/14/microservices-with-spring>



# Implementing Client-Side Load Balancing

- Discovery server may return the location of *multiple* instances
  - Recall: multiple instances for resilience and load-sharing
  - Client needs to pick one
- We will use Netflix Ribbon
  - Provides several algorithms for client-side load-balancing
- Spring provides a smart RestTemplate
  - Service-discovery and load-balancing built-in
  - @LoadBalanced



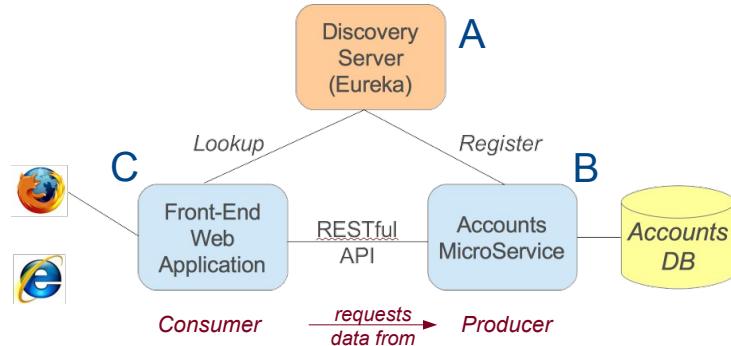
## Roadmap



- What is Microservices Architecture?
- Pros and Cons of Microservices
- Managing Microservices
- Tooling: Spring, Spring Cloud, Netflix
- **Building a Simple Microservice System**



## Our Simple Microservice System



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## Building our Simple Microservice System

- A) Run a Discovery Service
  - We will see how to create a Eureka Discovery Service
- B) Run a Microservice (the Producer)
  - Ensure it registers itself with the Discovery Service
  - Registers its *logical* service name with A
- C) How do Microservice Consumers find service B?
  - Discovery client using a “smart” RestTemplate
    - Spring performs service lookup for you
    - Uses *logical* service names in URLs

spring

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## Maven Dependencies



Dependencies for A, B & C. Spring Cloud is based on Spring Boot



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### (A) Eureka Server using Spring Cloud

- All you need to implement your own registry service!

# Not a client

```
@SpringBootApplication
@EnableEurekaServer
public class EurekaApplication {

    public static void main(String[] args) {
        SpringApplication.run(EurekaApplication.class, args);
    }
}
```

application.yml

```
server:
  port: 8761

eureka:
  instance:
    hostname: localhost
  client:
    registerWithEureka: false
    fetchRegistry: false
```

main.java

pom.xml

```
<dependency>
    <groupId>org.springframework.cloud</groupId>
    <artifactId>spring-cloud-starter-eureka-server</artifactId>
</dependency>
```



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## (B) Accounts Producer Microservice

Performs Service Registration

- Microservice declares itself as an available service
  - Using `@EnableDiscoveryClient`
  - Registers using its *application name*

```
@SpringBootApplication
@EnableDiscoveryClient
public class AccountsApplication {
    public static void main(String[] args) {
        SpringApplication.run(Application.class, args);
    }
}
spring:
  application:
    name: accounts-microservice
eureka:
  client:
    serviceUrl:
      defaultZone: http://localhost:8761/eureka/
```



## (C) Consumer Service – Step 1

Enable our consumer to find the producer

- Same annotation *also* allows service *lookup*

```
@SpringBootApplication
@EnableDiscoveryClient
public class FrontEndApplication {

    public static void main(String[] args) {
        SpringApplication.run(Application.class, args);
    }

    // Will use this template to access the microservice
    // Spring will enhance this to do service discovery
    @Bean @LoadBalanced
    public RestTemplate restTemplate() {
        return new RestTemplate();
    }
}
```

Same annotation as (B) –  
allows us to query Discovery  
Server to *find* microservices



## (C) Consumer Service – Step 2

Let our consumer use the producer

```
@Service  
public class RemoteAccountManager implements AccountService {  
  
    // Spring injects the “smart” service-aware template  
    // defined on previous slide  
    // It performs a load-balanced lookup (see next slide)  
    @Autowired  
    @LoadBalanced  
    RestTemplate restTemplate;  
  
    public Account findAccount(String id) {  
        // Fetch data  
        return restTemplate.getForObject  
            ("http://accounts-microservice/accounts/{id}",  
             Account.class, id);  
    }  
}
```

Service name



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## Load Balanced RestTemplate

- Create using `@LoadBalanced` – an `@Qualifier`
  - Spring enhances it to do service lookup & load-balancing

```
@Bean @LoadBalanced  
public RestTemplate restTemplate() {  
    return new RestTemplate();  
}
```

- Must inject using same qualifier
  - If there are multiple RestTemplates you get the right one
  - Can be used to access multiple microservices

```
@Autowired  
@LoadBalanced  
RestTemplate restTemplate;
```



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## Load Balancing with Ribbon

- Our “smart” RestTemplate automatically integrates *two* Netflix utilities
  - “Eureka” service-discovery
  - “Ribbon” client-side load-balancer
- End result
  - Eureka returns the URL of all available instances
  - Ribbon determines the best available service to use
- Just inject the load-balanced **RestTemplate**
  - Automatic lookup by *logical* service-name



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## Spring Cloud Resources



- We have only covered a *few* Spring Cloud features
  - Project Home page
    - <http://projects.spring.io/spring-cloud>
  - Matt Stine's *free* book on Cloud Native Architectures
    - <https://pivotallabs.com/migrating-to-cloud-native-application-architectures-ebook>
  - Spring Blog article
    - <https://spring.io/blog/2015/07/14/microservices-with-spring>

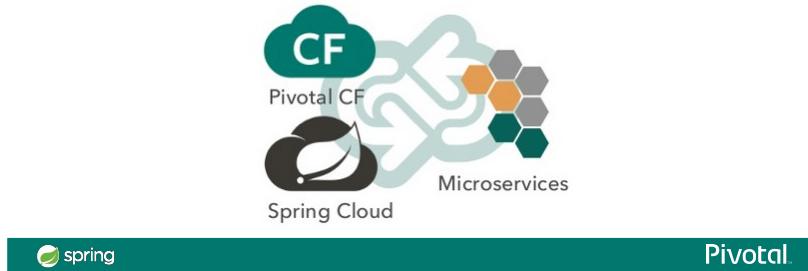
Consider taking our **Spring Cloud Services** course  
See: <http://pivotallabs.com/academy>



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## Summary

- After completing this lesson, you should have learned:
  - What is a Microservice Architecture?
  - Advantages and Challenges of Microservices
  - A little bit about Spring Cloud projects



# Finishing Up

Course Completed

What's Next?

## What's Next

- Congratulations, we've finished the course
- What to do next?
  - Certification
  - Other courses
  - Resources
  - Evaluation
- Check-out optional sections on Remoting and SOAP web-services



## Certification



- Computer-based exam
  - 50 multiple-choice questions
  - 90 minutes
  - Passing score: 76% (38 questions answered successfully)
- Preparation
  - Review all the slides
  - Redo the labs
  - Study Guide available online

<https://pivotal.io/academy/certification>



## Certification: Questions



### Sample question

- Statements
  - a. An application context holds Spring beans
  - b. An application context manages bean scope
  - c. Spring provides many types of application context
- Pick the correct response:
  1. Only a. is correct
  2. Both a. and c. are correct
  3. All are correct
  4. None are correct



## Certification: Logistics

- Where?
  - Online at PSI (Innovative Exams)
    - <https://www.examslocal.com>
- How?
  - You should receive a certification voucher by email
  - Register/sign-in and book an exam using the voucher
    - <http://it.psionline.com/exam-faqs/pivotal-faq>
  - Take the test from *any* location
- For more information, email
  - [education@pivotal.io](mailto:education@pivotal.io)

Voucher is  
valid for 3 months  
– *do it soon!*



## Other courses



- Many courses available
  - Spring Web
  - Enterprise Spring
  - Spring Boot Developer
  - Spring Cloud Services (Microservices with Spring)
  - Pivotal Cloud Foundry Developer
  - Pivotal Cloud Foundry Administration
  - Big Data and Analytics, Hadoop, Gemfire, ...
- See <https://pivotal.io/academy>



## Spring Web



- Four-day workshop
- Making the most of Spring in the web layer
  - Spring MVC using Spring Boot
  - REST using MVC and AJAX, CORS
  - Security of Web applications
  - Mock MVC testing framework
  - Spring Web Sockets
- Spring Web Application Developer certification



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## Enterprise Spring



- Building loosely coupled event-driven architectures
  - Separate processing, communications & integration
- 4 day course covering
  - Tasks, Scheduling and Concurrency
  - Advanced transaction management
  - REST Web Services with Spring MVC
  - Spring Integration
  - Spring Batch
  - Data Ingestion and Transformation



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# Spring Boot Developer



- 2 day workshop covering
  - Getting started with Spring Boot
  - Spring Boot CLI
  - Configuration, auto-configuration and profiles
  - Web development and REST
  - Data Access: JDBC, JPA, Spring Data, NoSQL
  - Testing
  - Security, Messaging
  - Deployment, Metrics, Actuator
  - Microservices



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## Spring Cloud Services Microservices With Spring



- Course topics:
  - Introduction to Spring Boot
    - Underpins all Spring Cloud projects
  - Pushing Applications to a PaaS
    - Using Pivotal Cloud Foundry
  - What are Microservices?
    - Architecting a microservices solution
  - Cloud infrastructure services and Netflix OSS
    - Service Configuration
    - Service Registration
    - Load-balancing and fault tolerance
    - Security using OAuth



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## Cloud Foundry Developer



CLOUD FOUNDRY

- 3 day course covering
  - Application deployment to Cloud Foundry
    - Deployment using `cf` tool or an IDE
    - Using the PCF Application Manager
  - Cloud Foundry Concepts
    - Logging, Continuous Integration, Monitoring
    - Accessing and defining Services
    - Using and customizing Buildpacks
  - Design considerations: “12 Factor”
    - JVM application specifics, using Spring Cloud

*Formerly: Developing Applications with Cloud Foundry*



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## Cloud Foundry Administration



CLOUD FOUNDRY

- 5 day course covering
  - Application deployment to Cloud Foundry
    - Logging, scaling, blue-green deployments
  - “Day 1 Operations”
    - Installation of PCF Ops Manager and Elastic Runtime
    - Configuring users, roles, and quotas
    - Capturing and reading logs
  - “Day 2 Operations”
    - Backing up and restoring an installation
    - Using BOSH
    - Upgrading Ops Manager and tiles.



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## Pivotal Support Offerings

- Global organization provides 24x7 support
  - How to Register: <http://tinyurl.com/piv-support>
- Premium and Developer support offerings:
  - <http://www.pivotal.io/support/offerings>
  - <http://www.pivotal.io/support/oss>
  - Both Pivotal App Suite *and* Open Source products
- Support Portal: <https://support.pivotal.io>
  - Community forums, Knowledge Base, Product documents



## Pivotal Consulting

- Custom consulting engagement?
  - Contact us to arrange it
    - <http://www.pivotal.io/contact/spring-support>
    - Even if you don't have a support contract!
- Pivotal Labs
  - Agile development experts
  - Mentoring: design, development and product management
    - <http://www.pivotal.io/agile>
    - <http://pivotallabs.com>



## Resources



- The Spring reference documentation
  - <http://spring.io/docs>
  - <http://projects.spring.io/spring-boot>
  - <http://projects.spring.io/spring-data>
  - <http://projects.spring.io/spring-security>
  - <http://projects.spring.io/spring-cloud>
- The official technical blog
  - <http://spring.io/blog>
- Stack Overflow – Active Spring Forums
  - <http://stackoverflow.com>



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## Resources (2)

- You can register issues on our Jira repository
  - <https://jira.spring.io>
- The source code is available here
  - <https://github.com/spring-projects/spring-framework>



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## Thank You!

- We hope you enjoyed the course
- Please fill out the evaluation form
  - Americas: <http://tinyurl.com/usa-eval>
  - EMEA: <http://tinyurl.com/emea-eval>
  - Asia-Pac: <http://tinyurl.com/apj-eval>
- Once you've done, login to *Pivotal Academy*
  - You can download your Attendance Certificate



*If your course  
is registered at  
Pivotal Academy*

*Don't forget the optional sections*



# XML Dependency Injection

Advanced Features & Best Practices

Techniques for Creating Reusable and Concise  
Bean Definitions

## Topics in this session

- **Singletons and Factory Beans**
- Constructor Arguments
- 'p' and 'c' namespaces
- Using Bean definition inheritance
- Inner Beans
- Lab
- Advanced Features
  - SpEL, Autowiring, Collections



## Advanced Bean Instantiation

- Four techniques:
  - @Bean method in @Configuration class
  - 100% Java code available, write whatever code you need
  - Beans implementing Spring's FactoryBean interface
  - Use XML factory-method attribute for Singletons
  - Define your own factories as Spring Beans in XML



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## Using a Java Singleton

- How can Spring instantiate the following?
  - Classes with private constructors (such as Singleton pattern below)

```
public class AccountServiceSingleton implements AccountService {  
    private static AccountServiceSingleton inst = new AccountServiceSingleton();  
  
    private AccountServiceSingleton() { ... }  
  
    public static AccountService getInstance() {  
        // ...  
        return inst;  
    }  
}
```



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## The factory-method Attribute

- Non-intrusive
  - Useful for existing Singletons or Factories

```
public class AccountServiceSingleton implements AccountService {  
    ...  
    public static AccountService getInstance() { // ... }  
}
```

```
<bean id="accountService" class="com.acme.AccountServiceSingleton"  
      factory-method="getInstance" />
```

*Spring configuration*

```
AccountService service1 = (AccountService) context.getBean("accountService");  
AccountService service2 = (AccountService) context.getBean("accountService");
```

Spring uses **getInstance()** method – so  
*service1* and *service2* point to the *same* object

*Test class*



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## Using Your Own Factories

- Spring allows one bean to create another
  - Create an instance of your factory as a bean
  - Use it to create another bean

```
<bean id="accountServiceFactory" class="com.acme.AccountServiceFactory">  
    <!-- any constructor-arg or property elements you need -->  
  </bean>  
  
<bean id="accountService" factory-bean="accountServiceFactory"  
      factory-method="create" />
```

*Spring configuration*

The **class** attribute is *illegal* here  
Will be determined by the factory



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## Topics in this session

- Singletons and Factory Beans
- **Constructor Arguments**
- 'p' and 'c' namespaces
- Using Bean definition inheritance
- Inner Beans
- Lab
- Advanced Features
  - SpEL, Autowiring, Collections



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## More on Constructor Args

- Constructor args matched by type
  - `<constructor-arg>` elements can be in
  - When ambiguous: indicate order with *index*

```
class MailService {  
    public MailService(String username, String email) { ... }
```

Both are Strings

```
<bean name="example" class="com.app.MailService">  
    <constructor-arg index="0" value="foo"/>  
    <constructor-arg index="1" value="foo@foo.com"/>  
</bean>
```

Index from zero



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## Using Constructor Types

- Can also specify the type
  - Typically when class has multiple ambiguous constructors

```
class MailService {  
    public MailService(String username) { ... }  
    public MailService(int maxMessages) { ... }
```

```
<bean name="example" class="com.app.MailService">  
    <constructor-arg type="int" value="2000"/>  
</bean>
```

Is a String in XML

Force use of second constructor  
Without type, Spring passes "2000" as the username



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## Using Constructor Names

- Constructor args can have names for matching
- Must be using Java 8 or later
  - OR: Need to compile with debug-symbols enabled
  - OR: Use `@java.beans.ConstructorProperties`

```
class MailService {  
    @ConstructorProperties( { "username", "email" } )  
    public MailService(String username, String email) { ... }
```

Specify arg  
names in order

```
<bean name="example" class="com.app.MailService">  
    <constructor-arg name="username" value="foo"/>  
    <constructor-arg name="email" value="foo@foo.com"/>  
</bean>
```

No index needed



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## Topics in this session

- Singletons and Factory Beans
- Constructor Arguments
- **'p' and 'c' namespaces**
- Using Bean definition inheritance
- Inner Beans
- Lab
- Advanced Features
  - SpEL, Autowiring, Collections



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## The *c* and *p* namespaces

- Before

```
<bean id="transferService" class="com.acme.BankServiceImpl"
    <constructor-arg ref="bankRepository"
    <property name="accountService" ref="accountService" />
    <property name="customerService" ref="customerService" />
</bean>
```

- After

```
<bean id="transferService" class="com.acme.BankServiceImpl"
    c:bankRepository-ref="bankRepository"
    p:accountService-ref="accountService"
    p:customer-service-ref="customerService" />
```

Use camel case or hyphens



c namespace is newer, introduced in Spring 3.1



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## The c and p namespaces

- c and p namespaces should be declared on top
  - Use '-ref' suffix for references

```
<beans xmlns:c="http://www.springframework.org/schema/c"
       xmlns:p="http://www.springframework.org/schema/p"
       ...>

    <bean id="transferService" class="com.acme.ServiceImpl"
          p:url="jdbc://..." p:service-ref="otherService" />
</beans>
```

Namespace declaration

Inject value for property 'url'

Inject reference to bean 'otherService'



## No schemaLocation needed

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

p and c namespace definitions

no extra schemaLocation entry required (no xsd)



## 'c' and 'p' Pros and Cons

- Pros
  - More concise
  - Well supported in STS
    - CTRL+space works well
- Cons
  - Less widely known than the usual XML configuration syntax



## Topics in this session

- Singletons and Factory Beans
- Constructor Arguments
- 'p' and 'c' namespaces
- **Using Bean definition inheritance**
- Inner Beans
- Lab
- Advanced Features
  - SpEL, Autowiring, Collections

## Bean Definition Inheritance (1)

- Sometimes several beans need to be configured in the same way
- Use bean definition inheritance to define the common configuration once
  - Inherit it where needed



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## Without Bean Definition Inheritance

```
<beans>
    <bean id="pool-A" class="org.apache.commons.dbcp.BasicDataSource">
        <property name="URL" value="jdbc:postgresql://server-a/transfer" />
        <property name="user" value="moneytransfer-app" />
    </bean>

    <bean id="pool-B" class="org.apache.commons.dbcp.BasicDataSource">
        <property name="URL" value="jdbc:postgresql://server-b/transfer" />
        <property name="user" value="moneytransfer-app" />
    </bean>

    <bean id="pool-C" class="org.apache.commons.dbcp.BasicDataSource">
        <property name="URL" value="jdbc:postgresql://server-c/transfer" />
        <property name="user" value="moneytransfer-app" />
    </bean>
</beans>
```

Can you find the duplication?



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## Abstract Parent bean

```
<beans>
    <bean id="abstractPool"
          class="org.apache.commons.dbcp.BasicDataSource" abstract="true">
        <property name="user" value="moneytransfer-app" />
    </bean>

    <bean id="pool-A" parent="abstractPool">
        <property name="URL" value="jdbc:postgresql://server-a/transfer" />
    </bean>
    <bean id="pool-B" parent="abstractPool">
        <property name="URL" value="jdbc:postgresql://server-b/transfer" />
    </bean>
    <bean id="pool-C" parent="abstractPool">
        <property name="URL" value="jdbc:postgresql://server-c/transfer" />
        <property name="user" value="bank-app" />
    </bean>
</beans>
```

Will not be instantiated

Can override

Each pool inherits its *parent* configuration



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## Default Parent Bean

```
<beans>

    <bean id="defaultPool" class="org.apache.commons.dbcp.BasicDataSource">
        <property name="URL" value="jdbc:postgresql://server-a/transfer" />
        <property name="user" value="moneytransfer-app" />
    </bean>

    <bean id="pool-B" parent="defaultPool">
        <property name="URL" value="jdbc:postgresql://server-b/transfer" />
    </bean>

    <bean id="pool-C" parent="defaultPool" class="example.SomeOtherPool">
        <property name="URL"
                  value="jdbc:postgresql://server-c/transfer" />
    </bean>

</beans>
```

Overrides URL property

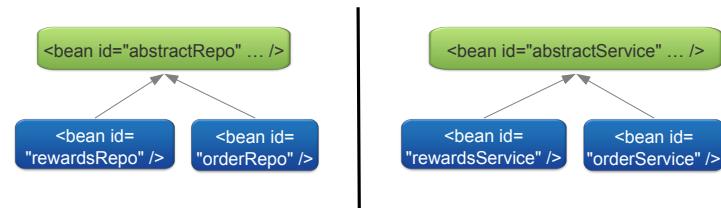
Overrides class as well



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## Inheritance for service and repository beans

- Bean inheritance commonly used for definition of Repository (or DAO) beans and (less often) Services



## Topics in this session

- Singletons and Factory Beans
- Constructor Arguments
- 'p' and 'c' namespaces
- Using Bean definition inheritance
- Inner Beans**
- Lab
- Advanced Features
  - SpEL, Autowiring, Collections



## Inner beans

- Inner bean only visible from surrounding bean

```
<bean id="restaurantRepository"
      class="rewards.internal.restaurant.JdbcRestaurantRepository">
    <property name="benefitAvailabilityPolicy">
      <bean class="rewards...DefaultBenefitAvailabilityPolicyFactory" />
    </property>
</bean>
```

No bean id

- Cannot be accessed from the ApplicationContext

```
applicationContext.getBean(RestaurantRepository.class); ← OK
applicationContext.getBean(DefaultBenefitAvailabilityPolicyFactory.class);
```

NoSuchBeanDefinitionException!!



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## Without an Inner Bean

```
<beans>
  <bean id="restaurantRepository"
        class="rewards.internal.restaurant.JdbcRestaurantRepository">
    <property name="dataSource" ref="dataSource" />
    <property name="benefitAvailabilityPolicyFactory" ref="factory" />
  </bean>
  <bean id="factory"
        class="rewards.internal.restaurant.availability.
        DefaultBenefitAvailabilityPolicyFactory">
    <constructor-arg ref="rewardHistoryService" />
  </bean>
  ...
</beans>
```

Can be referenced by other beans  
(even if it should not be)



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## With an Inner Bean

```
<beans>
    <bean id="restaurantRepository"
          class="rewards.internal.restaurant.JdbcRestaurantRepository">
        <property name="dataSource" ref="dataSource" />
        <property name="benefitAvailabilityPolicyFactory">
            <bean class="rewards.internal.restaurant.availability.
                DefaultBenefitAvailabilityPolicyFactory">
                <constructor-arg ref="rewardHistoryService" />
            </bean>
        </property>
    </bean>
    ...
</beans>
```

Inner bean has no id (it is anonymous)  
Cannot be referenced outside this scope



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## Multiple Levels of Nesting

```
<beans>
    <bean id="restaurantRepository"
          class="rewards.internal.restaurant.JdbcRestaurantRepository">
        <property name="dataSource" ref="dataSource" />
        <property name="benefitAvailabilityPolicyFactory">
            <bean class="rewards.internal.restaurant.availability.
                DefaultBenefitAvailabilityPolicyFactory">
                <constructor-arg>
                    <bean class="rewards.internal.rewards.JdbcRewardHistory">
                        <property name="dataSource" ref="dataSource" />
                    </bean>
                </constructor-arg>
            </bean>
        </property>
    </bean>
</beans>
```



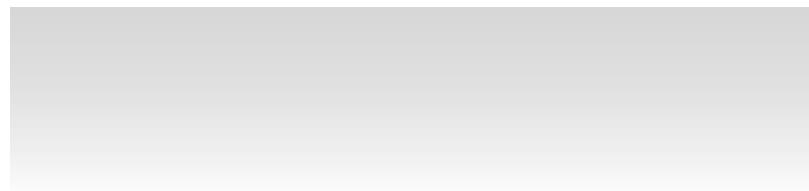
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## Inner Beans: pros and cons

- Pros
  - You only expose what needs to be exposed
  - Very commonly used technique in online examples
- Cons
  - Can be harder to read
  - Avoid really deep nesting
- General recommendation
  - Use them when it makes sense
    - As for inner classes in Java
    - Complex "infrastructure beans" configuration



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## Lab (Optional)

Using Bean Definition Inheritance, Property Placeholders and Namespaces



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## Topics in this session

- Singletons and Factory Beans
- Constructor Arguments
- 'p' and 'c' namespaces
- More on Profiles
- Externalizing values into properties files
- Using Bean definition inheritance
- Lab
- **Advanced Features**
  - SpEL, Autowiring, Collections



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## Spring Expression Language

- Can also be used in bean XML files
  - Same syntax that you have seen with @Value
  - Expressions in {} preceded by #
- Recall:
  - Can access System properties and environment
  - Properties of Spring beans



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## SpEL examples – XML

```
<bean id="rewardsDb" class="com.acme.RewardsTestDatabase">
    <property name="keyGenerator"
        value="#{strategyBean.databaseKeyGenerator}" />
</bean>

<bean id="strategyBean" class="com.acme.DefaultStrategies">
    <property name="databaseKeyGenerator" ref="myKeyGenerator"/>
</bean>

<bean id="taxCalculator" class="com.acme.TaxCalculator">
    <property name="defaultLocale" value="#{ systemProperties['user.region'] }"/>
</bean>
```

Can refer a nested property

Equivalent to System.getProperty(...)



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## SpEL Examples – Other Spring Projects

- In Spring Security

```
<security:intercept-url pattern="/accounts/**"
    access="isAuthenticated() and hasIpAddress('192.168.1.0/24') />
```

- In Spring Batch

```
<bean id="flatFileItemReader" scope="step"
    class="org.springframework.batch.item.file.FlatFileItemReader">
    <property name="resource" value="#{jobParameters['input.file.name']} />
</bean>
```



Spring Security will be discussed later in this course. Spring Batch is part of the "Spring Enterprise" course



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## Topics in this session

- Singletons and Factory Beans
- Constructor Arguments
- 'p' and 'c' namespaces
- Profiles
- Externalizing values into properties files
- Using Bean definition inheritance
- Lab
- **Advanced Features**
  - SpEL, Autowiring, Collections



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## Autowiring in XML

- XML had automatic wiring (setting) of dependencies before @Autowired – it's where the name comes from
- Can select *byType* or *byName* or *byConstructor*
  - *Cannot autowire both properties and constructor-args*
  - *Is inherently confusing and limited due to this difference*

```
<!-- Autowire properties (setters) by type matching just like @Autowired -->
<bean id="rewardsDb" autowire="byType" ... />

<!-- Autowire properties by name – just like @Resource -->
<bean id="accountManager" autowire="byName" ... />

<!-- Autowire constructors only by type – just like @Autowired -->
<bean id="accountManager" autowire="byConstructor" ... />
```



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## Topics in this session

- Singletons and Factory Beans
- Constructor Arguments
- 'p' and 'c' namespaces
- Profiles
- Externalizing values into properties files
- Using Bean definition inheritance
- Lab
- **Advanced Features**
  - SpEL, Autowiring, Collections



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## *beans* and *util* collections

- *beans* collections
  - From the default *beans* namespace
  - Simple and easy, legacy from Spring V1
- *util* collections
  - From the *util* namespace
    - Requires additional namespace declaration
  - More features available, since Spring V2



Both offer support for *set*, *map*, *list* and *properties* collections



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## Using the *beans* namespace

```
<bean id="service" class="com.acme.service.TransferServiceImpl">
    <property name="customerPolicies">
        <list>
            <ref bean="privateBankingCustomerPolicy"/>
            <ref bean="retailBankingCustomerPolicy"/>
            <bean class="com.acme.DefaultCustomerPolicy"/>
        </list>
    </property>
</bean>
```

```
public void setCustomerPolicies(java.util.List policies) { .. }
```

Equivalent to:

```
TransferServiceImpl service = new TransferServiceImpl();
service.setCustomerPolicies(list); // create list with bean references
```

ApplicationContext

```
service -> instance of TransferServiceImpl
```



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## *beans* collections limitation

- Can't specify the collection type
  - Example: *java.util.List* implementation is always *ArrayList*
- Collection has no bean id
  - Can't be accessed from the ApplicationContext
  - Only valid as inner beans

```
<bean id="service" class="com.acme.service.TransferServiceImpl">
    <property name="customerPolicies">
        <list> ... </list>
    </property>
</bean>
```

OK

NoSuchBeanDefinitionException!!

```
applicationContext.getBean("service");
applicationContext.getBean("customerPolicies");
```



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## Injecting a Set or Map

- Similar support available for Set

```
<property name="customerPolicies">
<set>
    <ref bean="privateBankingCustomerPolicy"/>
    <ref bean="retailBankingCustomerPolicy"/>
</set>
</property>
```

- Map (through map / entry / key elements)

```
<property name="customerPolicies">
<map>
    <entry key="001-pbcn" value-ref="privateBankingCustomerPolicy"/>
    <entry key-ref="keyBean" value-ref="retailBankingCustomerPolicy"/>
</map>
</property>
```

Key can use primitive type or ref to bean

value also supported



## Injecting a collection *Properties*

- Convenient alternative to a dedicated properties file
  - Use when property values are unlikely to change

```
<property name="config">
<value>
    server.host=mailer
    server.port=1010
</value>
</property>
```

```
<property name="config">
<props>
    <prop key="server.host">mailer</prop>
    <prop key="server.port">1010</prop>
</props>
</property>
```

```
public void setConfig(java.util.Properties props) { .. }
```



## *util* collections

- **util:** collections allow:
  - specifying collection implementation-type and scope
  - declaring a collection as a top-level bean

```
<bean id="service" class="com.acme.service.TransferServiceImpl"
      p:customerPolicies-ref="customerPolicies"/>

<util:set id="customerPolicies" set-class="java.util.TreeSet">
    <ref bean="privateBankingCustomerPolicy"/>
    <ref bean="retailBankingCustomerPolicy"/>
</util:set>
```

bean id

Implementation class

Also: util:list, util:map, util:properties



## *beans* or *util* collections?



- In most cases, the default collection elements in the beans namespace will suffice
  - But can *only* be inner beans
- Just remember the additional collection features in the **<util/>** namespace, in case you might need them
  - Declare a collection as a top-level bean
  - Specify collection implementation-type
- In the long-run, simpler to always use the **<util/>** namespace collection elements



## Summary

- Spring offers many techniques to simplify XML configuration
  - We've seen just a few here
  - It's about expressiveness and elegance, just like code
- Best practices we've discussed are used widely by many existing Spring XML projects
  - Imports, Bean Inheritance, Inner Beans ...
- Other features are more specialized



# Object Relational Mapping

Using OR Mapping in the Enterprise

Fundamental Concepts and Concerns

## Topics in this session

- The Object/Relational mismatch
- ORM in context
- Benefits of O/R Mapping

## The Object/Relational Mismatch (1)

- A domain object model is designed to serve the needs of the application
  - Organize data into abstract concepts that prove useful to solving the domain problem
  - Encapsulate behavior specific to the application
  - Under the control of the application developer



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## The Object/Relational Mismatch (2)

- Relational models relate business data and are typically driven by other factors:
  - Performance
  - Space
- Furthermore, a relational database schema often:
  - Predates the application
  - Is shared with other applications
  - Is managed by a separate DBA group



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## Object/Relational Mapping

- Object/Relational Mapping (ORM) engines exist to mitigate the mismatch
- Spring supports all of the major ones:
  - Hibernate
  - EclipseLink
  - Other JPA (Java Persistence API) implementations, such as OpenJPA
- This session will focus on Hibernate



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## Topics in this session

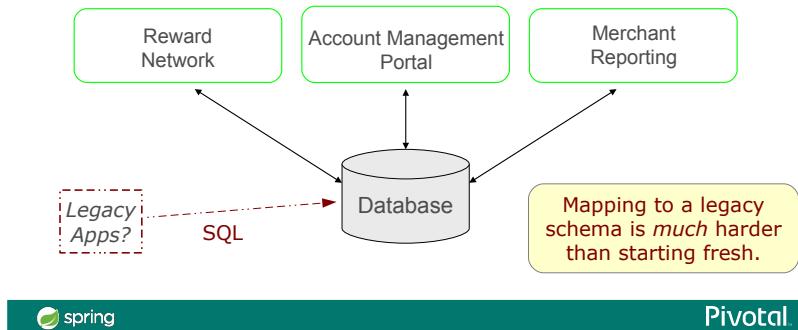
- The Object/Relational Mismatch
- **ORM in context**
- Benefits of modern-day ORM engines



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## ORM in context

- For the **Reward Dining** domain
  - The database schema already exists
  - Several applications share the data



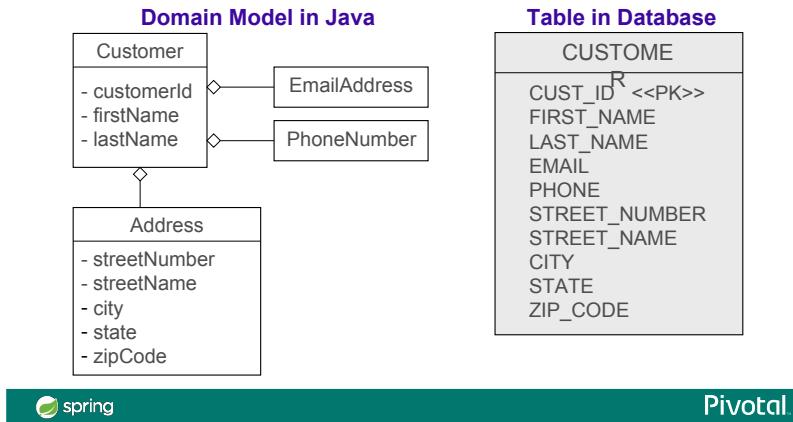
## O/R Mismatch: Granularity (1)

- In an object-oriented language, cohesive fine-grained classes provide encapsulation and express the domain naturally
- In a database schema, granularity is typically driven by normalization and performance considerations



## O/R Mismatch: Granularity (2)

*just one example...*



## O/R Mismatch: Identity (1)

- In Java, there is a difference between Object identity and Object equivalence:
  - $x == y$             *identity* (same memory address)
  - $x.equals(y)$       *equivalence*
- In a database, identity is based solely on primary keys:
  - $x.getEntityId().equals(y.getEntityId())$



## O/R Mismatch: Identity (2)

- When working with persistent Objects, the identity problem leads to difficult challenges
  - Two different Java objects may correspond to the same relational row
  - But Java says they are *not* equal
- Some of the challenges:
  - Implement equals() to accommodate this scenario
  - Determine when to update and when to insert
  - Avoid duplication when adding to a Collection



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## O/R Mismatch: Inheritance and Associations (1)

- In an object-oriented language:
  - *IS-A* relations are modeled with inheritance
  - *HAS-A* relations are modeled with composition
- In a database schema, relations are limited to what can be expressed by *foreign keys*



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## O/R Mismatch: Inheritance and Associations (2)

- Bi-directional associations are common in a domain model (e.g. Parent-Child)
  - This can be modeled naturally in each Object
- In a database:
  - One side (parent) provides a primary-key
  - Other side (child) provides a foreign-key reference
- For many-to-many associations, the database schema requires a *join table*



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## Topics in this session

- The Object/Relational Mismatch
- ORM in Context
- **Benefits of O/R Mapping**



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## Benefits of ORM

- Object Query Language
- Automatic Change Detection
- Persistence by Reachability
- Caching
  - Per-Transaction (1<sup>st</sup> Level)
  - Per-DataSource (2<sup>nd</sup> Level)



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## Object Query Language

- When working with domain objects, it is more natural to query based on objects.
  - Query with SQL:

```
SELECT c.first_name, c.last_name, a.city, ...
      FROM customer c, customer_address ca, address a
 WHERE ca.customer_id = c.id
   AND ca.address_id = a.id
   AND a.zip_code = 12345
```

- Query with object properties and associations:

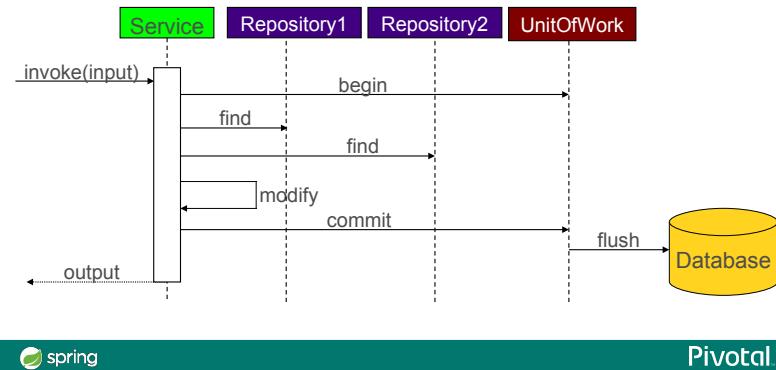
```
SELECT c FROM Customer c WHERE c.address.zipCode = 12345
```



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## Automatic Change Detection

- When a unit-of-work completes, all modified state will be synchronized with the database.



## Persistence by Reachability

- When a persistent object is being managed, other associated objects may become managed transparently:

```
Order order = orderRepository.findById(cid);
// order is now a managed object – retrieved via ORM

LineItem item = new LineItem(..);
order.addLineItem(item);
// item is now a managed object – reachable from order
```



## (Un)Persistence by Reachability = Make Transient

- The same concept applies for deletion:

```
Order order = orderRepository.findById(cid);
// order is now a managed object – retrieved via ORM

List<LineItem> items = order.getLineItems();
for (LineItem item : items) {
    if (item.isCancelled()) { order.removeLineItem(item); }
    // the database row for this item will be deleted
}
if (order.isCancelled()) {
    orderRepository.remove(order);
    // all item rows for the order will be deleted
}
```

The diagram illustrates the state transition of objects during deletion. It shows a sequence of code within a yellow box. Annotations with arrows point to specific parts of the code:

- An annotation "Item becomes transient" points to the line `if (item.isCancelled()) { order.removeLineItem(item); }`.
- An annotation "Order and all its items now transient" points to the line `if (order.isCancelled()) { orderRepository.remove(order); }`.



## Caching

- The first-level cache (1LC) is scoped at the level of a unit-of-work
  - When an object is first loaded from the database within a unit-of-work it is stored in this cache
  - Subsequent requests to load that same entity from the database will hit this cache first
- The second-level cache (2LC) is scoped at the level of the SessionFactory
  - Reduce trips to database for read-heavy data
  - Especially useful when a single application has exclusive access to the database



## Summary

- Managing persistent objects is hard
  - Especially if caching is involved
  - Especially on a shared, legacy schema with existing applications
- The ORM overcomes *some* of these problems
  - Automatic change detection, queries, caching
  - Ideal if your application *owns* its database
  - It is *not* a magic-bullet
    - JDBC may still be better for some tables/queries
    - True distributed cache coherency is *very* hard
    - *Design* for it and *test* performance



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# Spring Security XML Configuration

Classic configuration options for  
Web Application Security

Addressing Common Security Requirements

## Spring Security – XML Configuration

- Spring Security is also configurable via XML
  - Most common in older code bases
  - Some default behaviors are different.

## Configuration in web.xml

- web.xml configuration remains the same
  - springSecurityFilterChain
  - May also use Servlet 3.0 initializers

```
<filter>  
    <filter-name>springSecurityFilterChain</filter-name>  
    <filter-class>  
        org.springframework.web.filter.DelegatingFilterProxy  
    </filter-class>  
</filter>  
  
<filter-mapping>  
    <filter-name>springSecurityFilterChain</filter-name>  
    <url-pattern>*</url-pattern>  
</filter-mapping>
```

web.xml



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## intercept-url

- intercept-urls are evaluated in the order listed
  - first match is used, put specific matches first

```
<beans>  
    <security:http>  
  
        <security:intercept-url pattern="/accounts/edit*"  
            access="ROLE_ADMIN" />  
        <security:intercept-url pattern="/accounts/account**"  
            access="ROLE_ADMIN,ROLE_USER" />  
        <security:intercept-url pattern="/accounts/**"  
            access="IS_AUTHENTICATED_FULLY" />  
        <security:intercept-url pattern="/customers/**"  
            access="IS_AUTHENTICATED_ANONYMOUSLY" />  
  
    </security:http>  
</beans>
```



Syntax available since Spring Security 2.0



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## Security EL expressions

- hasRole('role')
  - Checks whether the principal has the given role
- hasAnyRole('role1', 'role2', ...)
  - Checks whether the principal has any of the given roles
- isAnonymous()
  - Allows access for unauthenticated principals
- isAuthenticated()
  - Allows access for authenticated or remembered principals



Available from Spring Security 3.0  
Previous syntax still works in Spring Security 3.0



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## Intercept-url and Expression Language

- Expression Language provides more flexibility
  - Many built-in expressions available

```
<beans>
    <security:http use-expressions="true"> ←
        <!-- Expression Language needs
             to be enabled explicitly -->
        <security:intercept-url pattern="/accounts/edit**"
            access="hasRole('ROLE_ADMIN')"/>
        <security:intercept-url pattern="/accounts/account**"
            access="hasAnyRole('ROLE_ADMIN', 'ROLE_USER')"/>
        <security:intercept-url pattern="/accounts/**"
            access="isAuthenticated() and hasIpAddress('192.168.1.0/24')"/>
    </security:http>
</beans>
```



Syntax available from Spring Security 3.0



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## Working with roles

- Checking if the user has one single role

```
<security:intercept-url pattern="/accounts/update*" access="hasRole('ROLE_ADMIN')"/>
```

- “or” clause

```
<security:intercept-url pattern="/accounts/update*"  
access="hasAnyRole('ROLE_ADMIN', 'ROLE_MANAGER')"/>
```

- “and” clause

```
<security:intercept-url pattern="/accounts/update*"  
access="hasRole('ROLE_ADMIN') and hasRole('ROLE_MANAGER')"/>
```

- Previous and new syntax can't be mixed

```
<security:intercept-url pattern="/accounts/update*"  
access="hasRole('ROLE_MANAGER')"/>  
<security:intercept-url pattern="/accounts/update*" access="ROLE_ADMIN"/>
```

Not correct!!



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## Specifying login and logout

```
<beans ...> (Spring Security 3.1)  
"security:beans"> http pattern  
  
<security:http use-expressions="true">  
    <security:form-login login-page="/accounts/login"  
        default-target-url="/accounts/home"/>  
  
    <security:intercept-url pattern="/accounts/update*"  
        access="hasAnyRole('ROLE_ADMIN', 'ROLE_MANAGER')"/>  
  
    <security:intercept-url pattern="/accounts/**"  
        access="hasRole('ROLE_ADMIN')"/>  
  
    <security:logout logout-success-url="/home.html"/>  
...  
</security:http>
```

Exempt login page

Specify login options

Must be declared explicitly  
or no logout possible

Spring configuration file



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## Setting up User Login

- Default auth. provider assumes form-based login
  - This is *web* security after all
  - Must* specify form-login element
  - A basic form is provided
  - Configure to use your own login-page

```
<security:http>
  <security:form-login/>
  ...
</security:http>

<security:authentication-manager>
  <security:authentication-provider>
  ...
  </security:authentication-provider>
<security:authentication-manager>
```

**Login with Username and Password**

User:

Password:



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## An Example Login Page

URL that indicates an authentication request

```
<form action="" method="POST">
  <input type="text" name="j_username"/>
  <br/>
  <input type="password" name="j_password"/>
  <br/>
  <input type="submit" name="submit" value="LOGIN"/>
</form>
```

The expected keys for generation of an authentication request token

*login-example.jsp*



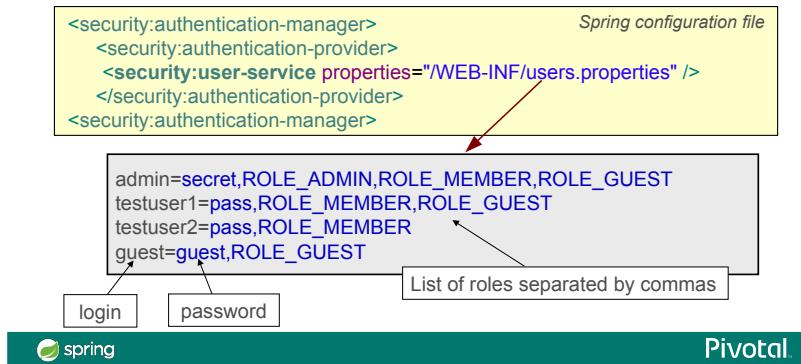
Above example shows default values (*j\_spring\_security\_check*, *j\_username*, *j\_password*). All of them can be redefined using `<security:form-login/>`



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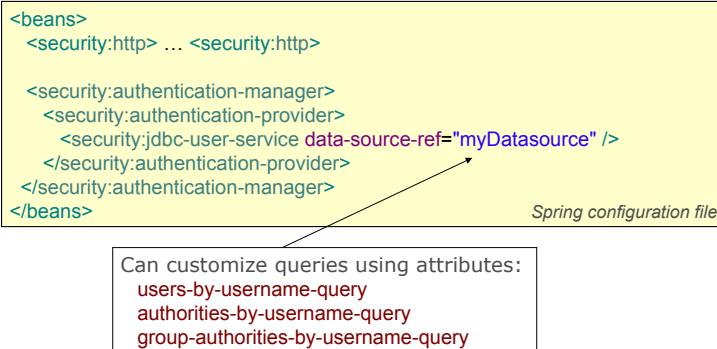
## The In-Memory User Service

- Useful for development and testing
  - Note: must restart system to reload properties



## The JDBC user service (2/2)

- Configuration:



## Password Encoding

- Can encode passwords using a hash
  - sha, md5, ...

```
<security:authentication-provider>
    <security:password-encoder hash="sha-256" /> ← simple encoding
        <security:user-service properties="/WEB-INF/users.properties" />
    </security:authentication-provider>
```

- Secure passwords using a well-known string
  - Known as a 'salt', makes brute force attacks harder

```
<security:authentication-provider>
    <security:password-encoder hash="sha-256" /> ← encoding with salt
        <security:salt-source system-wide="MySalt" />
    </security:password-encoder>
        <security:user-service properties="/WEB-INF/users.properties" />
    </security:authentication-provider>
```



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## Method Security using XML

- Can apply security to multiple beans with only a simple declaration

```
<security:global-method-security>
    <security:protect-pointcut
        expression="execution(* com.springframework.*Service.*(..))"
        access="ROLE_USER,ROLE_MEMBER" />
</security:global-method-security>
```

*Spring configuration file*



*Spring Security 2 syntax only. SpEL not supported here.*



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## Custom Filter Chain

- Filter on the stack may be **replaced** by a custom filter

```
<security:http>
  <security:custom-filter position="FORM_LOGIN_FILTER" ref="myFilter" />
</security:http>

<bean id="myFilter" class="com.mycompany.MySpecialAuthenticationFilter"/>
```

- Filter can be **added** to the chain

```
<security:http>
  <security:custom-filter after="FORM_LOGIN_FILTER" ref="myFilter" />
</security:http>

<bean id="myFilter" class="com.mycompany.MySpecialFilter"/>
```



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# Spring JMS

Simplifying Messaging Applications

JmsTemplate and Spring's Listener Container

## Topics in this Session

- **Introduction to JMS**
- Apache ActiveMQ
- Configuring JMS Resources with Spring
- Spring's JmsTemplate
- Sending Messages
- Receiving Messages
- Advanced Features

## Java Message Service (JMS)

- The JMS API provides an abstraction for accessing Message Oriented Middleware
  - Avoid vendor lock-in
  - Increase portability
- JMS does *not* enable different MOM vendors to communicate
  - Need a bridge (expensive)
  - Or use AMQP (standard msg protocol, like SMTP)
    - See RabbitMQ



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## JMS Core Components

- Message
- Destination
- Connection
- Session
- MessageProducer
- MessageConsumer



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## JMS Message Types

- Implementations of the Message interface
  - TextMessage
  - ObjectMessage
  - MapMessage
  - BytesMessage
  - StreamMessage



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## JMS Destination Types

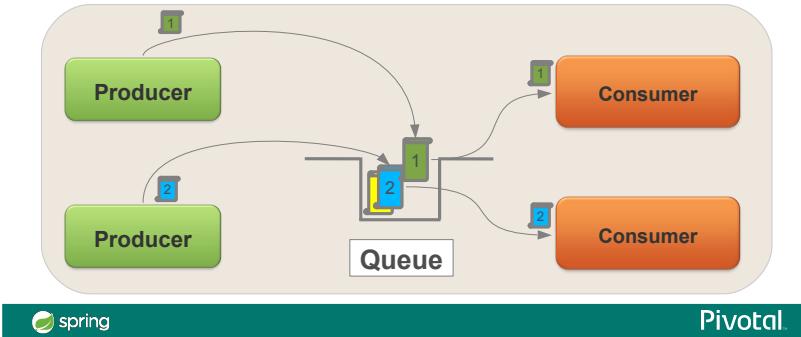
- Implementations of the Destination interface
  - Queue
    - Point-to-point messaging
  - Topic
    - Publish/subscribe messaging
- Both support *multiple* producers and consumers
  - Messages are different
  - Let's take a closer look ...



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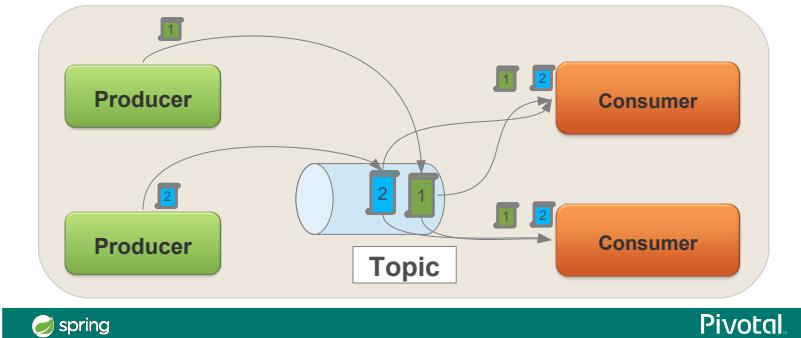
## JMS Queues: Point-to-point

1. Message sent to queue
2. Message queued
3. Message consumed by *single* consumer



## JMS Topics: Publish-subscribe

1. Message sent to topic
2. Message optionally stored
3. Message distributed to *all* subscribers



## The JMS Connection

- A JMS Connection is obtained from a factory

```
Connection conn = connectionFactory.createConnection();
```

- Typical enterprise application:
  - ConnectionFactory is a managed resource bound to JNDI

```
Properties env = new Properties();
// provide JNDI environment properties
Context ctx = new InitialContext(env);
ConnectionFactory connectionFactory =
    (ConnectionFactory) ctx.lookup("connFactory");
```



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## The JMS Session

- A Session is created from the Connection
  - Represents a unit-of-work
  - Provides transactional capability

```
Session session = conn.createSession(
    boolean transacted, int acknowledgementMode);

// use session
if (everythingOkay) {
    session.commit();
} else {
    session.rollback();
}
```



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## Creating Messages

- The Session is responsible for the creation of various JMS Message types

```
session.createTextMessage("Some Message Content");

session.createObjectMessage(someSerializableObject);

MapMessage message = session.createMapMessage();
message.setInt("someKey", 123);

BytesMessage message = session.createBytesMessage();
message.writeBytes(someByteArray);
```



## Producers and Consumers

- The Session is also responsible for creating instances of MessageProducer and MessageConsumer

```
producer = session.createProducer(someDestination);

consumer = session.createConsumer(someDestination);
```



## Topics in this Session

- Introduction to JMS
- **Apache ActiveMQ**
- Configuring JMS Resources with Spring
- Spring's JmsTemplate
- Sending Messages
- Receiving Messages
- Advanced Features



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## JMS Providers

- Most providers of Message Oriented Middleware (MoM) support JMS
  - WebSphere MQ, Tibco EMS, Oracle EMS, JBoss AP, SwiftMQ, etc.
  - Some are Open Source, some commercial
  - Some are implemented in Java themselves
- The lab for this module uses Apache ActiveMQ



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## Apache ActiveMQ

- Open source message broker written in Java
- Supports JMS and many other APIs
  - Including non-Java clients!
- Can be used stand-alone in production environment
  - 'activemq' script in download starts with default config
- Can also be used *embedded* in an application
  - Configured through ActiveMQ or Spring configuration
  - *What we use in the labs*



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## Apache ActiveMQ Features

Support for:

- Many cross language clients & transport protocols
  - Incl. excellent Spring integration
- Flexible & powerful deployment configuration
  - Clustering incl. load-balancing & failover, ...
- Advanced messaging features
  - Message groups, virtual & composite destinations, wildcards, etc.
- Enterprise Integration Patterns when combined with Spring Integration or Apache Camel
  - from the book by Gregor Hohpe & Bobby Woolf



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## Topics in this Session

- Introduction to JMS
- Apache ActiveMQ
- **Configuring JMS Resources with Spring**
- Spring's JmsTemplate
- Sending Messages
- Receiving Messages
- Advanced Features



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## Configuring JMS Resources with Spring

- Spring enables decoupling of your application code from the underlying infrastructure
  - Container provides the resources
  - Application is simply coded against the API
- Provides deployment flexibility
  - use a standalone JMS provider
  - use an application server to manage JMS resources



See: **Spring Framework Reference – Using Spring JMS**  
<http://docs.spring.io/spring/docs/current/spring-framework-reference/htmlsingle/#jms>



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## Configuring a ConnectionFactory

- ConnectionFactory may be standalone

```
@Bean  
public ConnectionFactory connectionFactory() {  
    ActiveMQConnectionFactory cf = new ActiveMQConnectionFactory();  
    cf.setBrokerURL("tcp://localhost:60606");  
    return cf;  
}
```

- Or retrieved from JNDI

```
@Bean  
public ConnectionFactory connectionFactory() throws Exception {  
    Context ctx = new InitialContext();  
    return (ConnectionFactory) ctx.lookup("jms/ConnectionFactory");  
}
```

```
<jee:jndi-lookup id="connectionFactory" jndi-name="jms/ConnectionFactory"/>
```



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## Configuring Destinations

- Destinations may be standalone

```
@Bean  
public Destination orderQueue() {  
    return new ActiveMQQueue( "order.queue" );  
}
```

- Or retrieved from JNDI

```
@Bean  
public Destination orderQueue() throws Exception {  
    Context ctx = new InitialContext();  
    return (Destination) ctx.lookup("jms/OrderQueue");  
}
```

```
<jee:jndi-lookup id="orderQueue" jndi-name="jms/OrderQueue"/>
```



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## Topics in this Session

- Introduction to JMS
- Apache ActiveMQ
- Configuring JMS Resources with Spring
- **Spring's JmsTemplate**
- Sending Messages
- Receiving Messages
- Advanced Features



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## Spring's JmsTemplate

- The template simplifies usage of the API
  - Reduces boilerplate code
  - Manages resources transparently
  - Converts checked exceptions to runtime equivalents
  - Provides convenience methods and callbacks

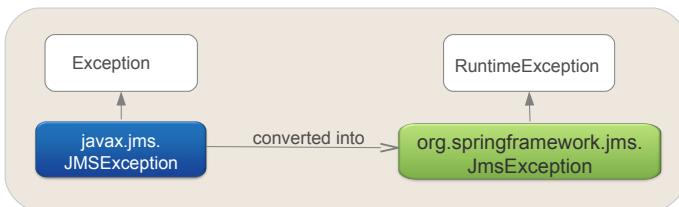
**NOTE:** The *AmqpTemplate* (used with RabbitMQ) has an almost identical API to the *JmsTemplate* – they offer similar abstractions over very different products



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## Exception Handling

- Exceptions in JMS are checked by default
- JmsTemplate converts checked exceptions to runtime equivalents



## JmsTemplate configuration

- Must provide reference to ConnectionFactory
  - via either constructor or setter injection
- Optionally provide other facilities
  - `setMessageConverter` (1)
  - `setDestinationResolver` (2)
  - `setDefaultDestination` or `setDefaultDestinationName` (3)

```
@Bean  
public JmsTemplate jmsTemplate () {  
    JmsTemplate template = new JmsTemplate( connectionFactory() );  
    template.setMessageConverter ( ... );  
    template.setDestinationResolver ( ... );  
    return template;  
}
```

(1), (2), (3) – see next few slides



## (1) MessageConverter

- The JmsTemplate uses a **MessageConverter** to convert between objects and messages
  - You only send and receive objects
- The default **SimpleMessageConverter** handles basic types
  - String to TextMessage
  - Map to MapMessage
  - byte[] to BytesMessage
  - Serializable to ObjectMessage

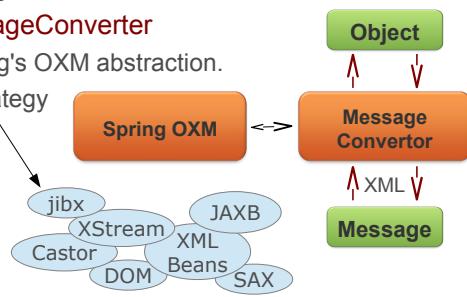


**NOTE:** It is possible to implement custom converters by implementing the *MessageConverter* interface



## XML MessageConverter

- XML is a common message payload
  - ...but there is no "XmlMessage" in JMS
  - Use *TextMessage* instead.
- MarshallingMessageConverter**
  - Plugs into Spring's OXM abstraction.
  - You choose strategy



## MarshallingMessageConverter Example

```
@Bean public JmsTemplate jmsTemplate () {  
    JmsTemplate template = new JmsTemplate( connectionFactory() );  
    template.setMessageConverter ( msgConverter() );  
    return template;  
}  
  
@Bean public MessageConverter msgConverter() {  
    MessageConverter converter = new MarshallingMessageConverter();  
    converter.setMarshaller ( marshaller() );  
    return converter;  
}  
  
@Bean public Marshaller marshaller() {  
    Jaxb2Marshaller marshaller = new Jaxb2Marshaller();  
    marshaller.setContextPath ( "example.app.schema" );  
    return marshaller;  
}
```

JAXB2 Illustrated here,  
other strategies  
available.



## (2) DestinationResolver

- Convenient to use destination names at runtime
- DynamicDestinationResolver used by default
  - Resolves topic and queue names
  - Not their Spring bean names
- JndiDestinationResolver also available



```
Destination resolveDestinationName(Session session,  
        String destinationName,  
        boolean pubSubDomain) throws JMSEException;
```

publish-subscribe?  
true q Topic  
false q Queue



## (3) Default Destination

- Used by default when sending *or* receiving messages

```
@Bean  
public JmsTemplate orderTemplate () {  
    JmsTemplate template = new JmsTemplate ( connectionFactory() );  
    template.setDefaultCloseOperation ( orderQueue() );  
    return template;  
}
```

Specify by Object

```
@Bean public JmsTemplate orderTemplate () {  
    JmsTemplate template = new JmsTemplate ( connectionFactory() );  
    template.setDefaultCloseOperationName ("order.queue");  
    return template;  
}
```

Specify by Name



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## Topics in this Session

- Introduction to JMS
- Apache ActiveMQ
- Configuring JMS Resources with Spring
- Spring's JmsTemplate
- Sending Messages**
- Receiving Messages
- Advanced Features



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## Sending Messages

- The template provides options
  - Simple methods to send a JMS message
  - One line methods that leverage the template's MessageConverter
  - Callback-accepting methods that reveal more of the JMS API
- Use the simplest option for the task at hand



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## Sending POJO

- A message can be sent in one single line

```
public class JmsOrderManager implements OrderManager {  
    @Autowired JmsTemplate jmsTemplate;  
    @Autowired Destination orderQueue;  
  
    public void placeOrder(Order order) {  
        String stringMessage = "New order " + order.getNumber();  
        jmsTemplate.convertAndSend("message.queue", stringMessage );  
        // use destination resolver and message converter  
  
        jmsTemplate.convertAndSend(orderQueue, order); // use message converter  
  
        jmsTemplate.convertAndSend(order); // use converter and default destination  
    }  
}
```

No @Qualifier so Destination is wired by name



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## Sending JMS Messages

- Useful when you need to access JMS API
  - eg. set expiration, redelivery mode, reply-to ...

```
public void sendMessage(final String msg) {  
    this.jmsTemplate.send( (session) -> {  
        TextMessage message = session.createTextMessage(msg);  
        message.setJMSExpiration(2000); // 2 seconds  
        return message;  
    });  
}  
  
public interface MessageCreator {  
    public Message createMessage(Session session)  
        throws JMSException;  
}
```

Lambda syntax



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## Topics in this Session

- Introduction to JMS
- Apache ActiveMQ
- Configuring JMS Resources with Spring
- Spring's JmsTemplate
- Sending Messages
- **Receiving Messages**
- Advanced Features



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## Receiving Objects

- JmsTemplate can also *receive* data
  - Automatically converted using MessageConverter
  - Underlying messages hidden

```
public void receiveData() {  
  
    // use message converter and destination resolver  
    String s = (String) jmsTemplate.receiveAndConvert("message.queue");  
    // use message converter  
    Order order1 = (Order) jmsTemplate.receiveAndConvert(orderQueue);  
    // use message converter and default destination  
    Order order2 = (Order) jmsTemplate.receiveAndConvert();  
}
```



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## Receiving Messages

- Or you may access the underlying message
  - Gives you access to message properties

```
public void receiveMessages() {  
  
    // handle JMS native message from default destination  
    ObjectMessage orderMessage = (ObjectMessage) jmsTemplate.receive();  
    Order order2 = (Order) orderMessage.getObject();  
  
    // receive(destination) and receive(destinationName) also available  
}
```



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## Synchronous Message Exchange

- JmsTemplate also implements a request/reply pattern
  - Using `sendAndReceive()`
  - Sending a message and blocking until a reply has been received (also uses `receiveTimeout()`)
  - Manage a temporary reply queue automatically by default

```
public void processMessage(String msg) {  
  
    Message reply = jmsTemplate.sendAndReceive("message.queue",  
        (session) -> {  
            return session.createTextMessage(msg);  
        });  
    // handle reply  
}
```



## Asynchronous or Synchronous

*Sync*  
*Async*

- Sending messages is asynchronous
  - The send methods return immediately
    - Even if the message takes time to be delivered
    - Recall the acknowledgement modes in `createSession()`
- But `receive()` and `receiveAndConvert()` are blocking
  - Synchronous – will wait for ever for a new message
    - optional timeout: `setReceiveTimeout()`
- How can we receive data asynchronously?
  - JMS defines *Message Driven Beans*
  - But you normally need a full JEE container to use them



## Spring's MessageListener Containers

- Spring provides containers for asynchronous JMS reception
  - *SimpleMessageListenerContainer*
    - Uses plain JMS client API
    - Creates a fixed number of Sessions
  - *DefaultMessageListenerContainer*
    - Adds transactional capability
- Many configuration options available for each container type



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## Quick Start

Steps for Asynchronous Message Handling

- (1) Define POJO / Bean to process Message
- (2) Define JmsListenerContainerFactory / Enable Annotations
- (3) Annotate POJO to be message-driven



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## Step (1)

### Define POJO / Bean to Process Message

- Define a POJO to process message

- Note: No references to JMS

```
public class OrderServiceImpl {
    @JmsListener(destination="queue.order")
    @SendTo("queue.confirmation")
    public OrderConfirmation order(Order o) { ... }
}
```

- Define as a Spring bean using XML, JavaConfig, or annotations as preferred
  - @**JmsListener** enables a JMS message consumer for the method
  - @**SendTo** defines response destination (optional)

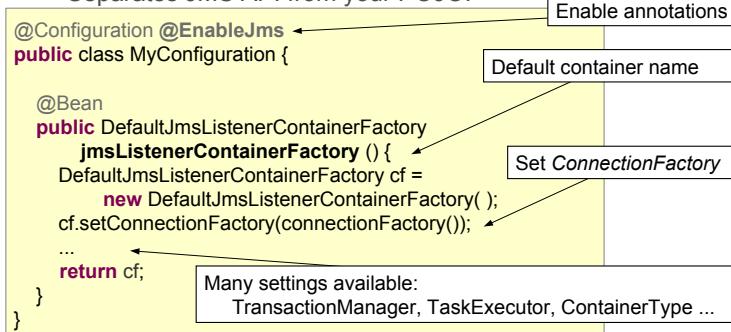
## Step (2)

### Define JmsListenerContainerFactory to use

- JmsListenerContainerFactory

- Separates JMS API from your POJO:

```
@Configuration @EnableJms
public class MyConfiguration {
    @Bean
    public DefaultJmsListenerContainerFactory
        jmsListenerContainerFactory() {
        DefaultJmsListenerContainerFactory cf =
            new DefaultJmsListenerContainerFactory();
        cf.setConnectionFactory(connectionFactory());
        ...
        return cf;
    }
}
```



The diagram illustrates the configuration of the `jmsListenerContainerFactory()` method. It shows the following annotations and their corresponding configurations:

- `@Configuration @EnableJms`: Points to a yellow box labeled "Enable annotations".
- `@Bean`: Points to a yellow box labeled "Default container name".
- `public DefaultJmsListenerContainerFactory`: Points to a yellow box labeled "Set ConnectionFactory".
- `jmsListenerContainerFactory()`: Points to a yellow box labeled "Many settings available: TransactionManager, TaskExecutor, ContainerType ...".
- `new DefaultJmsListenerContainerFactory()`: Points to the same yellow box labeled "Many settings available: TransactionManager, TaskExecutor, ContainerType ...".
- `cf.setConnectionFactory(connectionFactory());`: Points to the same yellow box labeled "Many settings available: TransactionManager, TaskExecutor, ContainerType ...".
- `...`: Points to the same yellow box labeled "Many settings available: TransactionManager, TaskExecutor, ContainerType ...".
- `return cf;`: Points to the same yellow box labeled "Many settings available: TransactionManager, TaskExecutor, ContainerType ...".

## Step (3)

### Define Receiving Method with @JmsListener

- Container with name **jmsListenerContainerFactory** is used by default

```
public class OrderServiceImpl {
    @JmsListener(containerFactory="myFactory",
                 destination="orderConfirmation")
    public void process(OrderConfirmation o) { ... }
}
```

- Can also set a custom concurrency or a payload selector

```
public class OrderServiceImpl {
    @JmsListener(selector="type = 'Order'",
                 concurrency="2-10", destination = "order")
    public OrderConfirmation order(Order o) { ... }
}
```



## Using JMS: Pros and Cons

- Advantages
  - Application freed from messaging concerns
    - Resilience, guaranteed delivery (compare to REST)
  - Asynchronous support built-in
  - Interoperable – languages, environments
- Disadvantages
  - Requires additional third-party software
    - Can be expensive to install and maintain
  - More complex to use – *but not with JmsTemplate!*

*Spring Enterprise – 4 day course on application integration*



# Lab

## Sending and Receiving Messages in a Spring Application

**Coming Up:** Spring's Caching Connection Factory



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### Topics in this Session

- Introduction to JMS
- Apache ActiveMQ
- Configuring JMS Resources with Spring
- Spring's JmsTemplate
- Sending Messages
- Receiving Messages
- **Optional Features**
  - **Using XML**



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## Alternative Step (2)

### Use JMS XML Namespace Support

- Equivalent Capabilities
  - The **containerId** attribute exposes the configuration of the container with that name
  - Same configuration options available
    - task execution strategy, concurrency, container type, transaction manager and more

```
<jms:annotation-driven>  
  
<jms:listener-container  
    containerId="jmsMessageContainerFactory"  
    connection-factory="myConnectionFactory"/>  
  
<bean id="orderService" class="org.acme.OrderService"/>
```



## 100% XML Equivalent

- Use *jms:listener-container* with embedded *jms:listeners*
  - Supports multiple listeners in a single declaration
  - Same configuration options available

```
<jms:listener-container connection-factory="myConnectionFactory">  
    <jms:listener destination="order.queue"  
        ref="orderService"  
        method="order"  
        response-destination="confirmation.queue" />  
    <jms:listener destination="confirmation.queue"  
        ref="orderService"  
        method="confirm" />  
</jms:listener-container>  
  
<bean id="orderService" class="org.acme.OrderService"/>
```

No need for `@JmsListener`



## Message-Driven POJO in XML

- Listener unpacks incoming payload
  - Uses the MessageConverter
  - Invokes method on POJO
  - Return value sent to response-destination after conversion

```
public class OrderService { ①  
    public OrderConfirmation order(Order o) {  
        ②  
    } ③
```

```
<jms:listener  
    ref="orderService" ①  
    method="order" ②  
    destination="queue.orders"  
    response-destination="queue.confirmation"/>
```



## CachingConnectionFactory

- JmsTemplate aggressively closes and reopens resources like Sessions and Connections
  - Lots of overhead and poor performance
  - Normally these are cached by connection factory
- Use our *CachingConnectionFactory* to add caching within the application if needed

```
<bean id="connectionFactory"  
    class="org.springframework.jms.connection.CachingConnectionFactory">  
    <property name="targetConnectionFactory">  
        <bean class="org.apache.activemq.ActiveMQConnectionFactory">  
            <property name="brokerURL" value="vm://embedded?broker.persistent=false"/>  
        </bean>  
    </property>  
</bean>
```



# Performance and Operations

Management and Monitoring of Spring Java Applications

Exporting Spring Beans to JMX

## Topics in this Session

J M X

- **Introduction**
- JMX
- Introducing Spring JMX
- Automatically exporting existing MBeans
- Spring Insight

## Overall Goals

- Gather information about application during runtime
- Dynamically reconfigure app to align to external occasions
- Trigger operations inside the application
- Even adapt to business changes in smaller scope



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## Topics in this Session

- Introduction
- **JMX**
- Introducing Spring JMX
- Automatically exporting existing MBeans
- Spring Insight



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## What is JMX?

- The **Java Management Extensions** specification aims to create a standard API for adding management and monitoring to Java applications
- Management
  - Changing configuration properties at runtime
- Monitoring
  - Reporting cache hit/miss ratios at runtime



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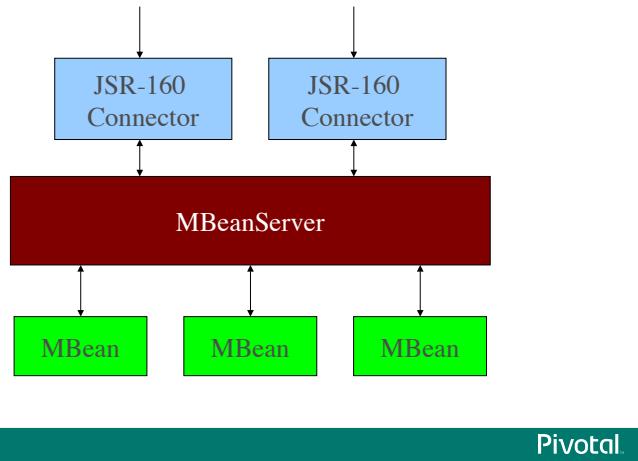
## How JMX Works

- To add this management and monitoring capability, JMX instruments application components
- JMX introduces the concept of the MBean
  - An object with management metadata



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## JMX Architecture



## JMX Architecture

- MBeanServer acts as broker for communication between
  - Multiple local MBeans
  - Remote clients and MBeans
- MBeanServer maintains a keyed reference to all MBeans registered with it
  - *object name*
- Many generic clients available
  - JDK: jconsole, jvisualvm

## JMX Architecture

- An MBean is an object with additional management metadata
  - Attributes (→ properties)
  - Operations (→ methods)
- The management metadata can be defined statically with a Java interface or defined dynamically at runtime
  - Simple MBean or Dynamic MBean respectively



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## Plain JMX – Example Bean

```
public interface JmxCounterMBean {  
    int getCount(); // becomes Attribute named 'Count'  
    void increment(); // becomes Operation named 'increment'  
}
```

```
public class JmxCounter implements JmxCounterMBean {  
    ...  
    public int getCount() {...}  
    public void increment() {...}  
}
```



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## Plain JMX – Exposing an MBean

```
MBeanServer server = ManagementFactory.getPlatformMBeanServer();

JmxCounter bean = new JmxCounter(...);

try {
    ObjectName name = new ObjectName("ourapp:name=counter");
    server.registerMBean(bean, name);
} catch (Exception e) {
    e.printStackTrace();
}
```



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## Topics in this Session

- Introduction
- JMX
- **Introducing Spring JMX**
- Automatically exporting existing MBeans
- Spring Insight



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## Goals of Spring JMX

- Using the raw JMX API is difficult and complex
- The goal of Spring's JMX support is to simplify the use of JMX while hiding the complexity of the API



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## Goals of Spring JMX

- Configuring JMX infrastructure
  - Declaratively using context namespace or FactoryBeans
- Exposing Spring beans as MBeans
  - Annotation based metadata
  - Declaratively using Spring bean definitions
- Consuming JMX managed beans
  - Transparently using a proxy-based mechanism



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## Spring JMX Steps

1. Configuring MBean Server
2. Configure Exporter
3. Control Attribute / Operation Exposure.



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### Step 1: Creating an MBeanServer

- Use context namespace to locate or create an MBeanServer

```
<context:mbean-server />
```

XML

- Or declare it explicitly

```
@Bean  
public MBeanServerFactoryBean mbeanServer () {  
    MBeanServerFactoryBean server = new MBeanServerFactoryBean();  
    server.setLocateExistingServerIfPossible( true );  
    ...  
    return server;  
}
```

or JavaConfig



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## Step 2: Exporting a Bean as an MBean

- Start with one or more existing POJO bean(s)

```
<bean id="messageService" class="example.MessageService"/>
```

- Use the MBeanExporter to export it

By default: *all public* properties exposed as attributes, *all public* methods exposed as operations.

```
@Bean  
public MBeanExporter mbeanExporter () {  
    MBeanExporter exporter = new MBeanExporter();  
    exporter.setAutodetect ( true );  
    ...  
    return exporter;  
}
```

JavaConfig

`<context:mbean-export/>`

or XML



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## Step 1 & 2: JavaConfig Shortcut

- One annotation defines server and exporter:

```
@Configuration  
@EnableMBeanExport  
public class MyConfig {  
    ...  
}
```

Specific server bean  
configurable if desired.



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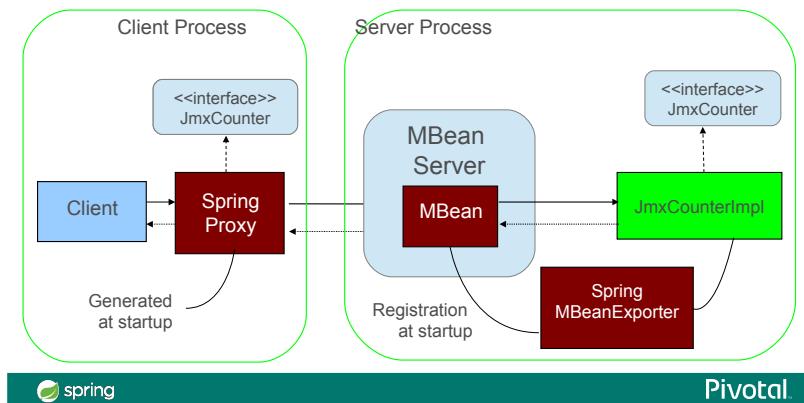
### 3. Control Attribute/Operation Exposure:

- Combine Annotations with Exporter:
  - Only annotated attributes/operations exposed.

```
@ManagedResource(objectName="statistics:name=counter",
                  description="A simple JMX counter")
public class JmxCounterImpl implements JmxCounter {
    @ManagedAttribute(description="The counter value")
    public int getCount() {...}
    @ManagedOperation(description="Increments the counter value")
    public void increment() {...}
}
```



### Spring in the JMX architecture



## Topics in this session

- Introduction
- JMX
- Introducing Spring JMX
- **Automatically exporting existing MBeans**
- Spring Insight



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## Automatically Exporting Pre-existing MBeans

- Some beans are MBeans themselves
  - Example: Log4j's LoggerDynamicMBean
  - Spring will auto-detect and export them for you

```
<context:mbean-export>

<bean class="org.apache.log4j.jmx.LoggerDynamicMBean">
    <constructor-arg>
        <bean class="org.apache.log4j.Logger"
              factory-method="getLogger"/>
        <constructor-arg value="org.springframework.jmx" />
    </bean>
</constructor-arg>
</bean>
```



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## Topics in this session

- Introduction
- JMX
- Introducing Spring JMX
- Automatically exporting existing MBeans
- **Spring Insight**



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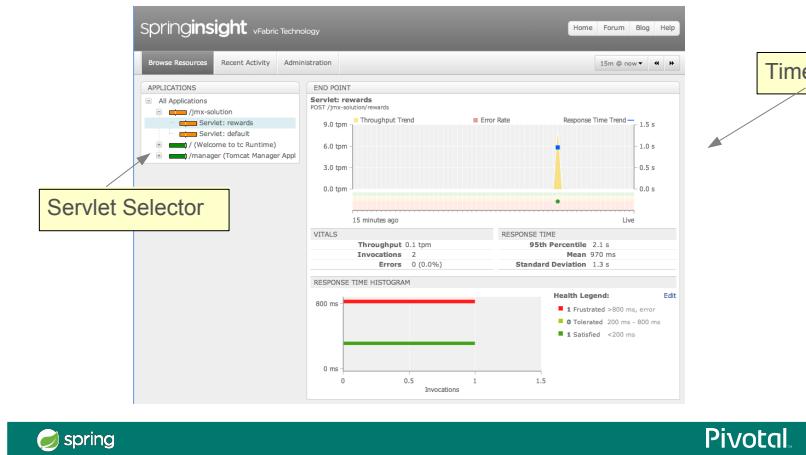
## Spring Insight Overview

- Part of tc Server Developer Edition
  - Monitors web applications deployed to tc Server
  - <http://localhost:8080/insight>
- Focuses on what's relevant
  - esp. performance related parts of the application
- Detects performance issues during development
  - Commercial version for production: *vFabric APM*



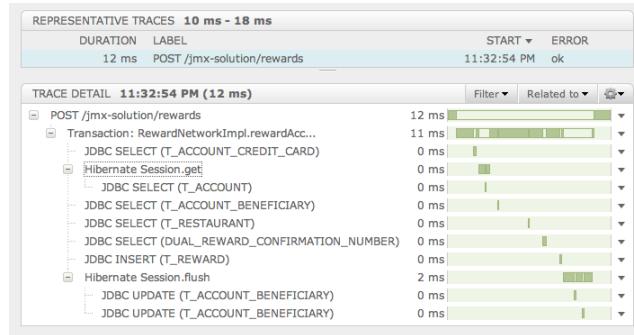
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## Spring Insight Overview



## Spring Insight Overview

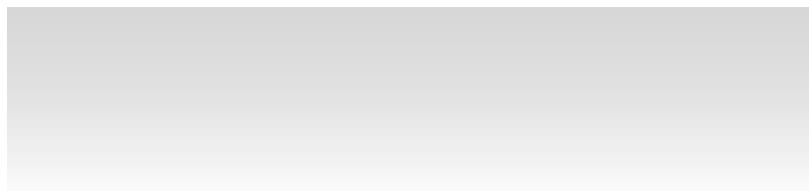
- A request trace from HTTP POST to SQL



- Spring JMX
  - Export Spring-managed beans to a JMX MBeanServer
  - Simple value-add now that your beans are managed
- Steps
  - Create MBean server
  - Automatically export annotated and pre-existing Mbeans
    - Use `@EnableMBeanExport` or `<context:mbean-server>` and `<context:mbean-export>`
  - Use Spring annotations to declare JMX metadata
- Spring Insight (tc Server Developer Edition)
  - Deep view into your web-application in STS



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## Optional Lab

Monitoring and Managing a Java Application



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