Pivotal

JPA with Spring

Object Relational Mapping with Spring and Java Persistence API

Objectives

- After completing this lesson, you should be able to:
  - Explain the basic concepts of JPA
  - Configure JPA using Spring
  - Implement a JPA DAO
  - Explain how JPA Integration is implemented by Spring

Agenda

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

Introduction to JPA

- The Java Persistence API (JPA) is designed for operating on domain objects
  - Defined as POJO entities
  - No special interface required

- A common API for object-relational mapping
  - Derived from experience with existing products
    - JBoss Hibernate
    - Oracle TopLink (now EclipseLink)

About JPA

- Java Persistence API
  - Current version: 2.2 – released mid-2017
- Configuration
  - Persistence Unit
- Key Features
  - Entity Manager
  - Entity Manager Factory
  - Persistence Context

JPA Configuration

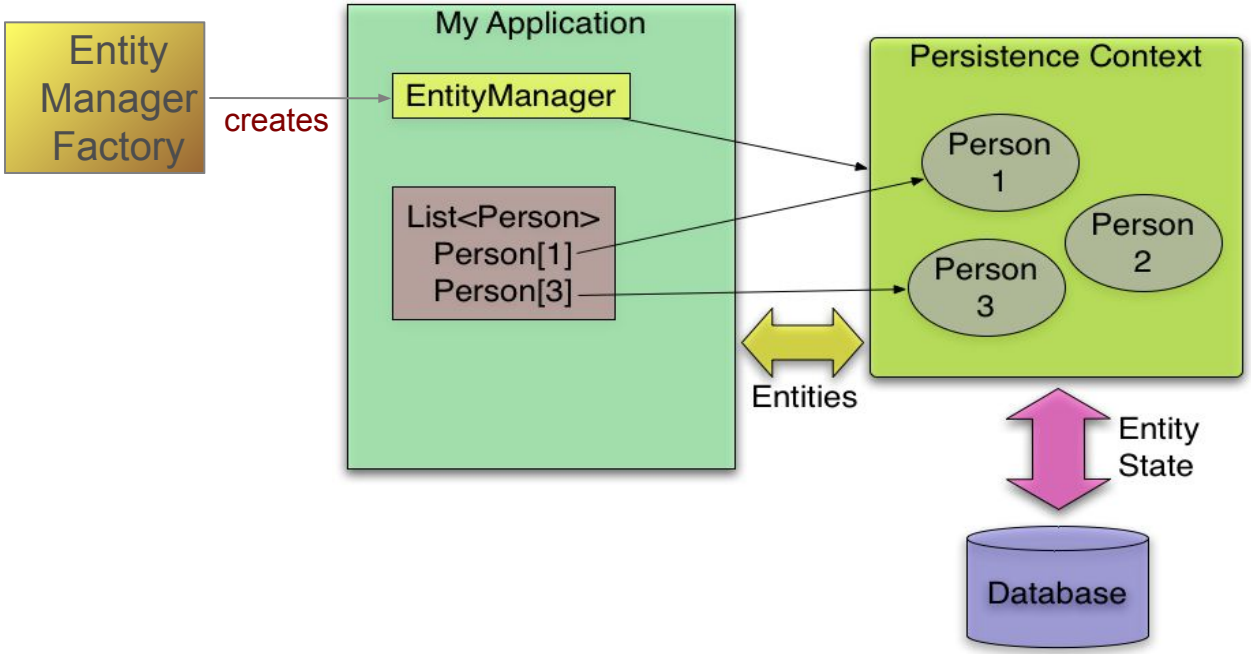
- **Persistence Unit**
  - Describes a group of persistent classes (entities)
  - Defines provider(s)
  - Defines transactional types (local vs JTA)
  - Multiple Units per application are allowed
  - Defined by the file: **`persistence.xml`**

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

Persistence Context and EntityManager



The EntityManager API

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

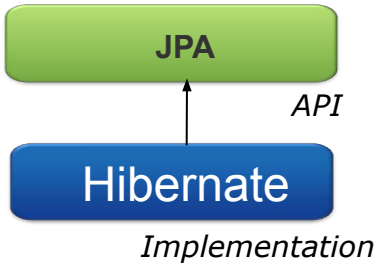
Plus many other methods ...

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

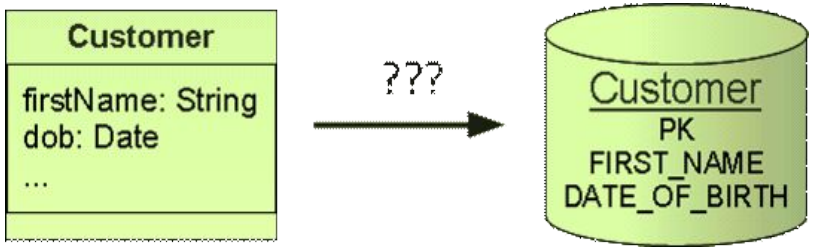
Hibernate JPA

- 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

Only *@Entity* and *@Id* are mandatory

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

Mapping Using Accessors (Properties)

Must place @Id on the *getter* method

Other annotations now also placed on *getter* methods

```
@Entity @Table(name= “T_CUSTOMER”)
public class 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; }
}
```

Relationships

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

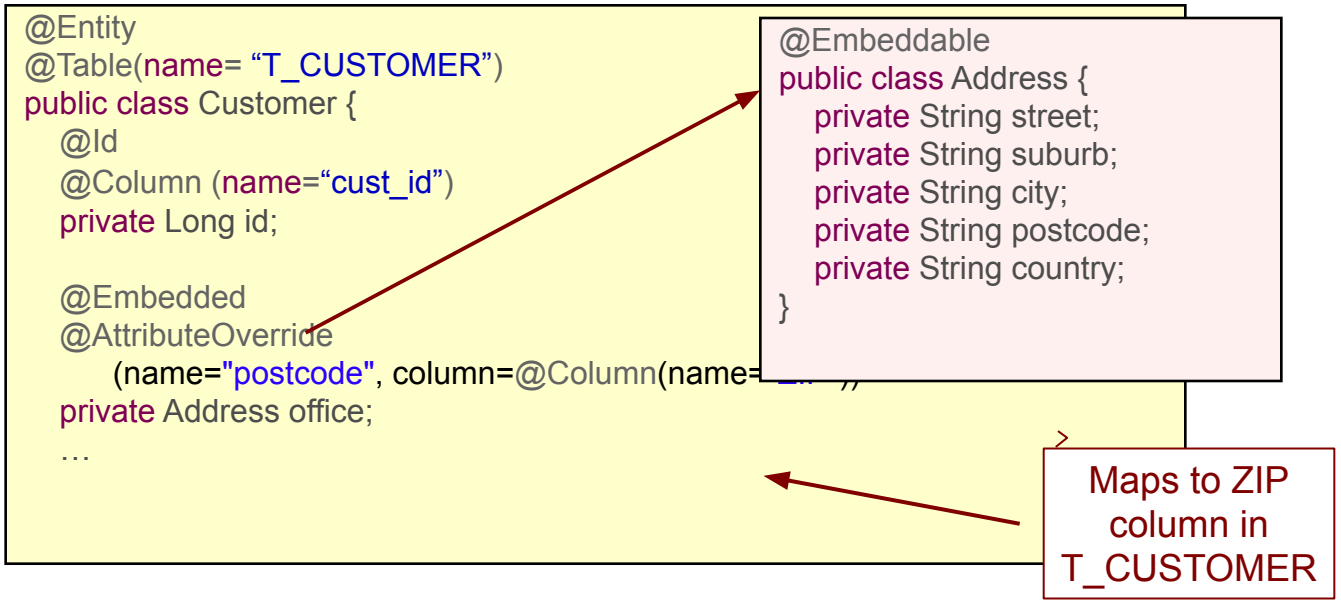
```
@Entity
@Table(name= "T_CUSTOMER")
public class Customer {
   @Id
   @Column (name="cust_id")
   private Long id;

   @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



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
  - 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*

Agenda

- Introduction to JPA
- **Configuring JPA in Spring**
- Optional and Advanced Topics

Quick Start – Spring JPA Configuration

- Steps to using JPA with Spring

1. Define Mapping Metadata (already covered)
2. Define an EntityManagerFactory bean.
3. Define Transaction Manager and DataSource beans
4. Define Repository/DAO

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

2. 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 Spring's *packagesToScan* property

3. Transaction Manager & DataSource

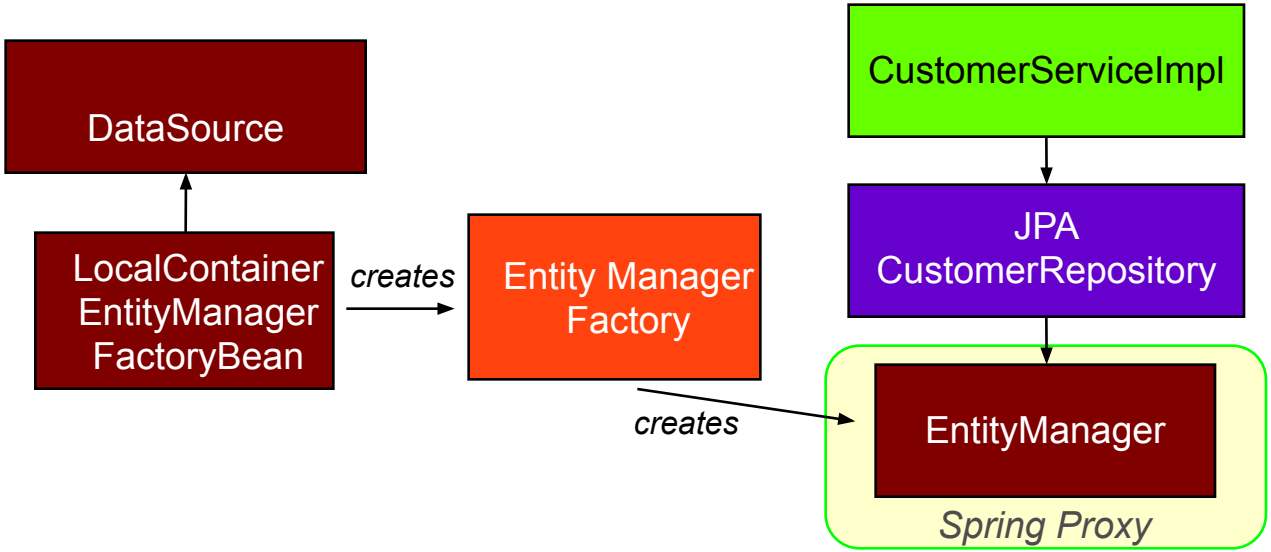
```
@Bean
public LocalContainerEntityManagerFactoryBean entityManagerFactory() {
    // See previous slide
    ...
    return entityManagerFactoryBean;
}


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


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

Method returns a *FactoryBean*...

… Spring calls getObject() on the FactoryBean to obtain the *EntityManagerFactory*:

Or … use `JtaTransactionManager`

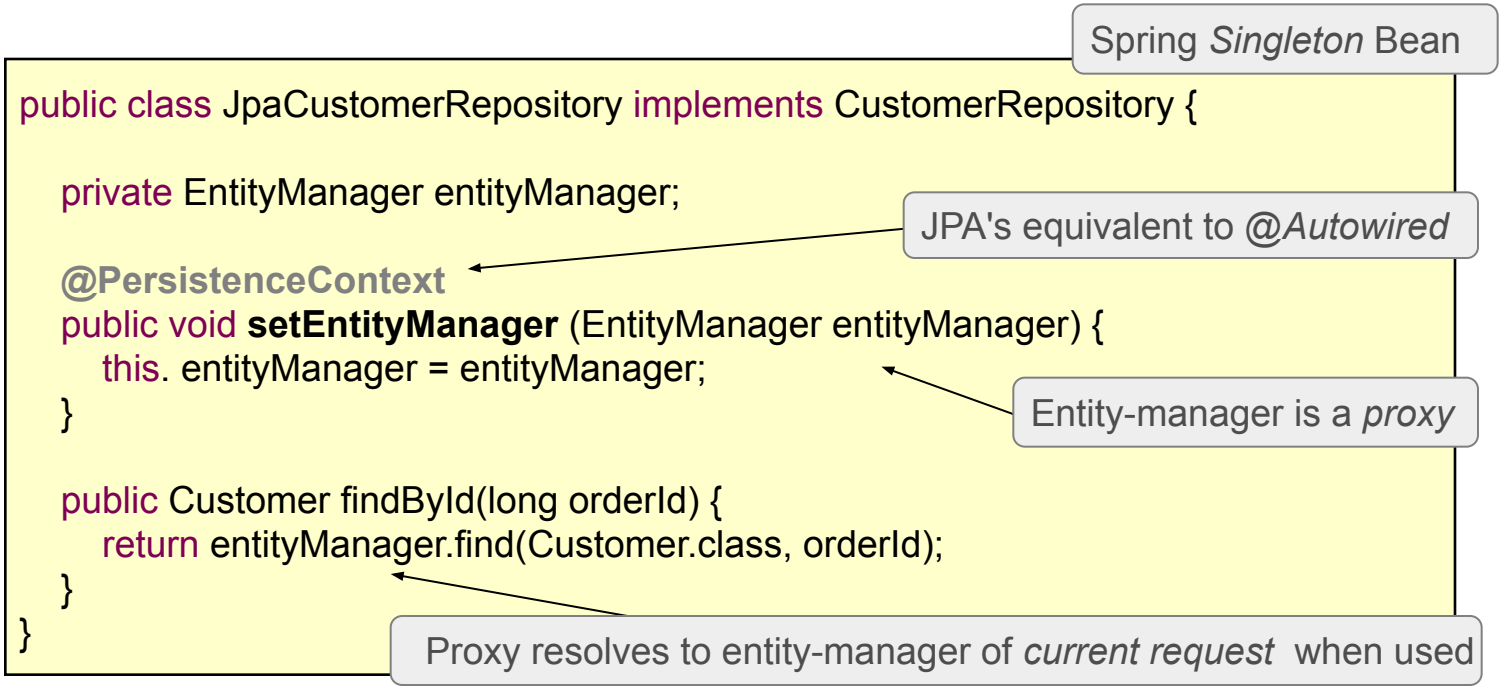
EntityManagerFactoryBean Configuration



Proxy automatically finds entity-manager for current transaction

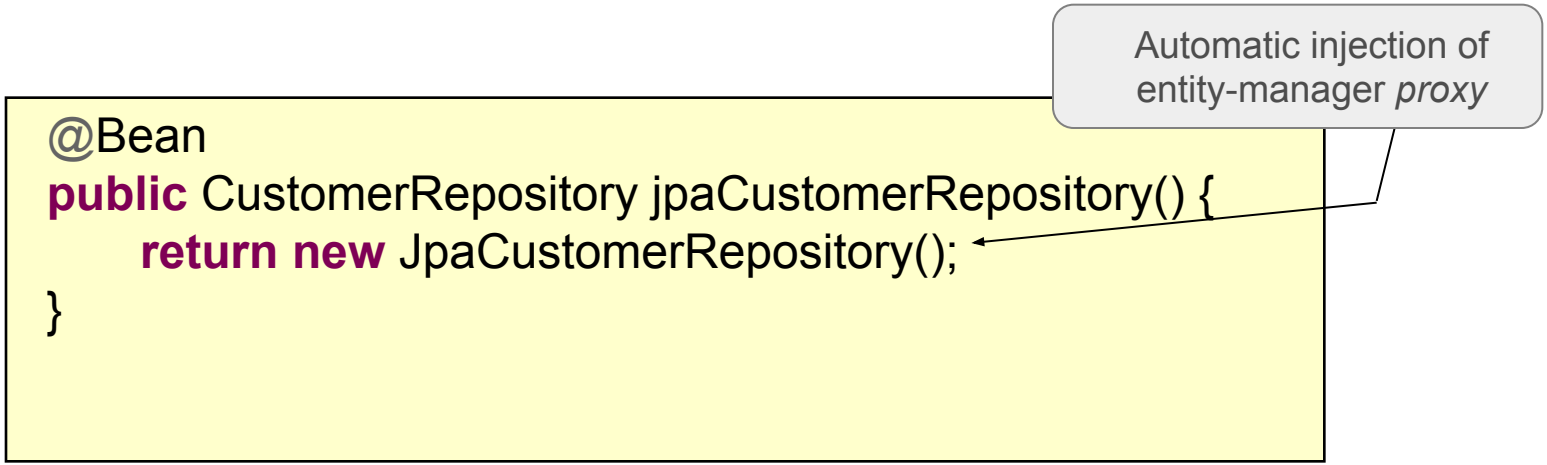
4. Implementing JPA Repository

- The code – *no Spring dependencies*



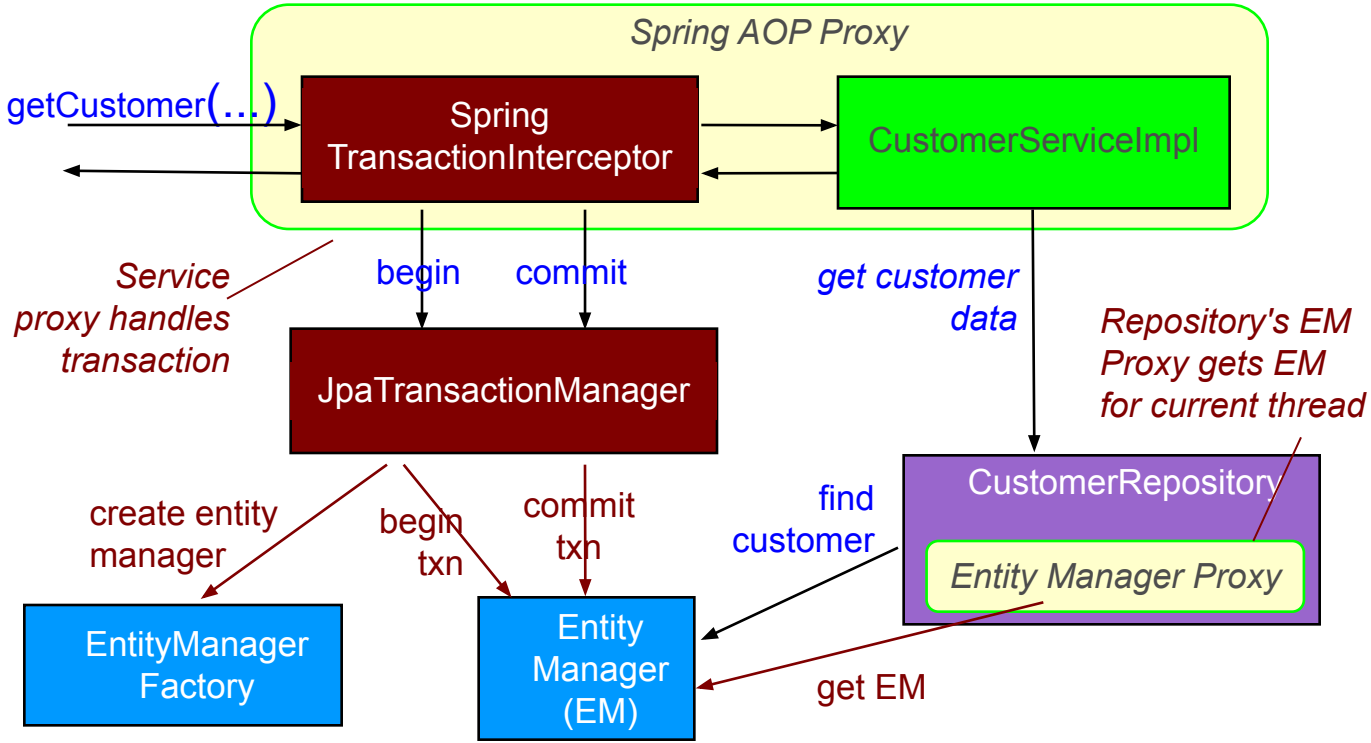
Define JPA Repository as Spring Bean

- The definition
  - No need to explicitly call **`setEntityManager()`**



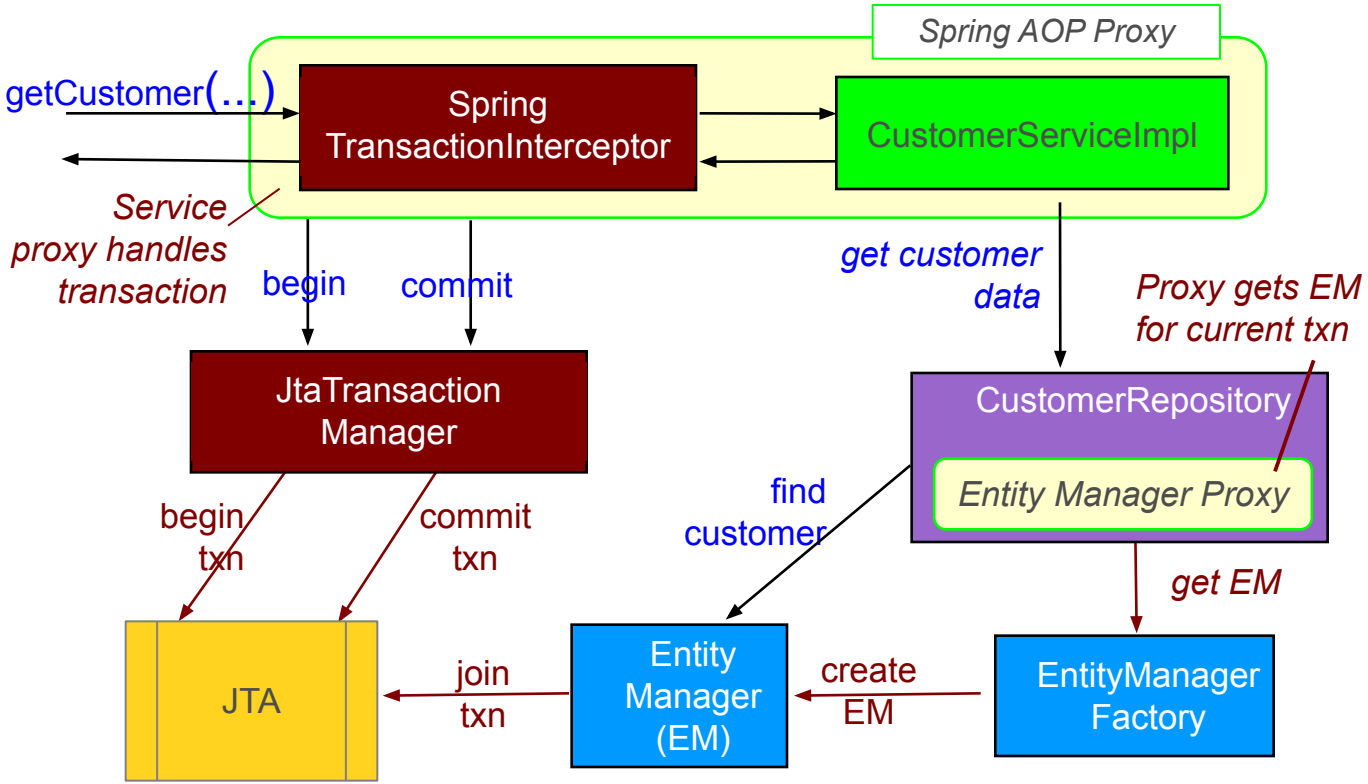
How it Works (JPA)

Spring defines *where* transactions are … JPA *implements* them



How it Works (JTA)

Spring defines *where* transactions are
… JTA *implements* them
… JPA joins and uses them



Implementing JPA DAOs with Spring

- Spring defines *where* transactions occur
  - Delegates to a JPA EntityManager to implement them
  - Supports local or global (JTA) transactions

- *EntityManager is a* "proxy"
  - Allows a singleton Repository to access the right *EntityManager* for current transaction in current thread

- There are *no* Spring dependencies in your Repository (DAO) implementations

Summary

- Use 100% JPA to define entities and access data
  - Repositories have no Spring dependency
- Use Spring to configure JPA entity-manager factory
  - Smart proxy works with Spring-driven transactions
  - Spring defines where transactions begin & end
  - JPA entity-managers implements them

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- Introduction to JPA
- Configuring JPA in Spring
- **Optional and Advanced Topics**
  - **Exception Translation**
  - JPA Typed Queries / Native Queries
  - EntityManagerFactoryBean alternatives / persistence.xml

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

Transparent Exception Translation (2)

- Spring provides this capability out of the box
  - Annotate with **`@Repository`**
  - Is also an **`@Component`**, so will be found by component-scanner

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

Transparent Exception Translation (3)

- Make Spring apply AOP to the the annotated repository
  - Requires a Spring-provided BeanPostProcessor
    - **`PersistenceExceptionTranslationPostProcessor`**
  - If any Spring bean defines **`PersistenceException-Translator`**
    - Spring creates a **`PersistenceException-TranslationPostProcessor`** bean *automatically*
- **`LocalContainerEntityManagerFactoryBean`** does this for you
  - All you need to do is use **`@Repository`**

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- **Optional and Advanced Topics**
  - Exception Translation
  - **JPA Typed Queries / Native Queries**
  - EntityManagerFactoryBean alternatives / persistence.xml

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_.lastNname), lastName);
    cq.where(condition);

    return entityManager.createQuery(cq).getResultList();
}
```

Meta-data class created by JPA (note underscore)

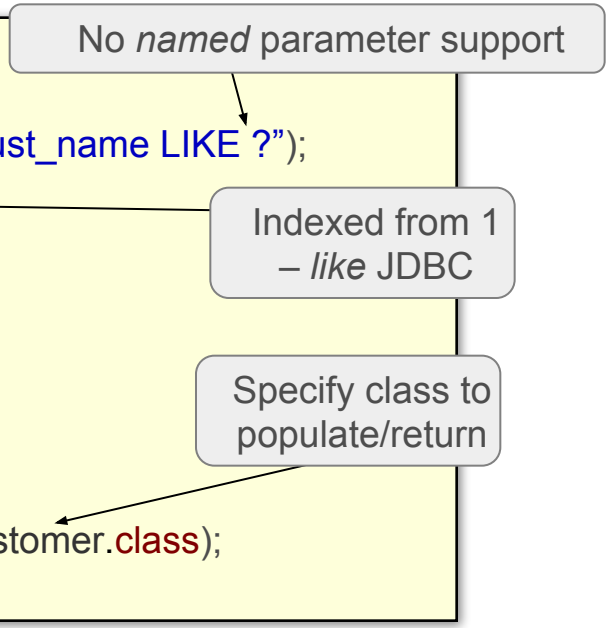
JPA Querying: SQL

- 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();
```



Agenda

- Introduction to JPA
- Configuring JPA in Spring
- **Optional and Advanced Topics**
  - Exception Translation
  - JPA Typed Queries / Native Queries
  - **EntityManagerFactoryBean alternatives / persistence.xml**

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

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 required by JPA, optional when using Spring with JPA!

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 *and* Persistence Unit

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

Minimal Spring Configuration

```
<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>
```

Do JPA configuration in persistence.xml

If using JTA, declare *<jta-data-source>* in persistence.xml

JNDI Lookups

- JNDI lookup used to retrieve an *EntityManagerFactory* from an application server
  - Use when deploying to JEE Application Servers
    - WebSphere, WebLogic, JBoss, Glassfish …

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

Topics Covered

- Introduction to JPA
- Configuring JPA in Spring
- Optional and Advanced Topics