CS520 Web Programming

Object-Relational Mapping with Hibernate and JPA

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The Object-Oriented Paradigm

- The world consists of objects
- So we use object-oriented languages to write applications
- We want to store some of the application objects (a.k.a. persistent objects)
- So we use a Object Database?

The Reality of DBMS

- Relational DBMS are still predominant
  - Best performance
  - Most reliable
  - Widest support
- Bridge between OO applications and relational databases
  - CLI and embedded SQL
  - Object-Relational Mapping (ORM) tools

Call-Level Interface (CLI)

- Application interacts with database through functions calls

```
String sql = "select name from items where id = 1";

Connection c = DriverManager.getConnection( url );
Statement stmt = c.createStatement();
ResultSet rs = stmt.executeQuery( sql );

if( rs.next() )  System.out.println( rs.getString("name") );
```

Embedded SQL

- SQL statements are embedded in host language

```
String name;
#sql {select name into :name from items where id = 1};
System.out.println( name );
```

Employee – Application Object

```
public class Employee {

    Integer    id;
    String     name;
    Employee   supervisor;

}
```

Employee – Database Table

```
create table employees (

    id            integer primary key,
    name          varchar(255),
    supervisor    integer references employees(id)

);
```

From Database to Application

- So how do we construct an Employee object based on the data from the database?

```
public class Employee {

        Integer       id;
        String        name;
        Employee      supervisor;

    public Employee( Integer id )
    {
        // access database to get name and supervisor
        … …
    }
}
```

Problems with CLI and Embedded SQL …

- SQL statements are hard-coded in applications

```
public Employee( Integer id ) {
    …
    PreparedStatment p;
    p = connection.prepareStatment(
        "select * from employees where id = ?"
    );
    …
}
```

… Problems with CLI and Embedded SQL …

- Tedious translation between application objects and database tables

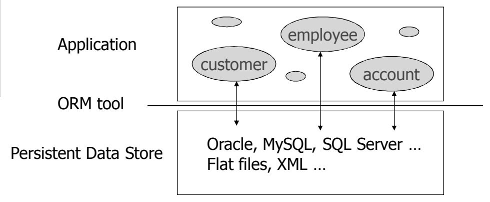
```
public Employee( Integer id ) {
    …
    ResultSet rs = p.executeQuery();
    if( rs.next() )
    {
        name = rs.getString("name");
        …
    }
}
```

… Problems with CLI and Embedded SQL

- Application design has to work around the limitations of relational DBMS

```
public Employee( Integer id ) {
    …
    ResultSet rs = p.executeQuery();
    if( rs.next() )
    {
        …
        supervisor = ??
    }
}
```

The ORM Approach



Advantages of ORM

- Make RDBMS look like ODBMS
- Data are accessed as objects, not rows and columns
- Simplify many common operations. E.g. System.out.println(*e.supervisor.name*)
- Improve portability
  - Use an object-oriented query language (OQL)
  - Separate DB specific SQL statements from application code
- Caching

Hibernate and JPA

- Java Persistence API (JPA)
  - Annotations for object-relational mapping
  - Data access API
  - An object-oriented query language JPQL
- Hibernate
  - The most popular Java ORM library
  - An implementation of JPA

Hibernate Usage

- Hibernate without JPA
  - API: `SessionFactory, Session, Query, Transaction`
  - More features
- Hibernate with JPA
  - API: `EntityManagerFactory, EntityManager, Query, Transaction`
  - Better portability
  - Behaviors are better defined and documented

A Hibernate Example

- Java classes
  - `Employee.java`
- JPA configuration file
  - `persistence.xml`
- Code to access the persistent objects
  - `EmployeeTest.java`
- (Optional) Logging configuration files
  - `log4j.properties`

Java Classes

- Plain Java classes (POJOs); however, it is *recommended* that
  - Each persistent class has an identity field
  - Each persistent class implements the Serializable interface
  - Each persistent field has a pair of getter and setter, *which don't have to be public*

O/R Mapping Annotations

- Describe how Java classes are mapped to relational tables

@Entity	Persistent Java Class
@Id	Id field
@Basic (can be omitted)	Fields of simple types
@ManyToOne @OneToMany @ManyToMany @OneToOne	Fields of class types

persistence.xml

- <persistence-unit>
  - `name`
- <properties>
  - Database information
  - Provider-specific properties
- No need to specify persistent classes

Access Persistent Objects

- `EntityManagerFactory`
- **`EntityManager`**
- `Query` and `TypedQuery`
- `Transaction`
  - A transaction is required for updates

Some EntityManager Methods

- find(entityClass, primaryKey)
- createQuery(query)
- createQuery(query, resultClass)
- persist(entity)
- merge(entity)
- getTransaction()

http://sun.calstatela.edu/~cysun/documentation/jpa-2.0-api/javax/persistence/EntityManager.html

Persist() vs. Merge()

Scenario	Persist	Merge
Object passed was never persisted	1. Object added to persistence context as new entity 2. New entity inserted into database at flush/commit	1. State copied to new entity. 2. New entity added to persistence context 3. New entity inserted into database at flush/commit 4. New entity returned
Object was previously persisted, but not loaded in this persistence context	1. EntityExistsException thrown (or a PersistenceException at flush/commit)	1. Existing entity loaded. 2. State copied from object to loaded entity 3. Loaded entity updated in database at flush/commit 4. Loaded entity returned
Object was previously persisted and already loaded in this persistence context	1. EntityExistsException thrown (or a PersistenceException at flush or commit time)	1. State from object copied to loaded entity 2. Loaded entity updated in database at flush/commit 3. Loaded entity returned

http://blog.xebia.com/2009/03/jpa-implementation-patterns-saving-detached-entities/

Java Persistence Query Language (JPQL)

- A query language that looks like SQL, but for accessing *objects*
- Automatically translated to DB-specific SQL statements
- `select e from Employee e where e.id = :id`
  - From all the Employee objects, find the one whose id matches the given value

See Chapter 4 of Java Persistence API, Version 2.0

Hibernate Query Language (HQL)

- A superset of JPQL
- http://docs.jboss.org/hibernate/core/3.6/reference/en-US/html/queryhql.html
- CSNS Examples
  - `CourseDaoImpl`
  - `QuarterDaoImpl`

Join in HQL …

```
class User {

    Integer id;
    String username;
    …
}
```

```
class Section {

    Integer id;
    User instructor;
    …
}
```

users

id	username
1	cysun
2	vcrespi

sections

id	instructor_id
1	1
2	1
3	2

… Join in HQL …

- Query: find all the sections taught by the user "cysun".
  - *SQL??*
  - *HQL??*

… Join in HQL …

```
class User {

    Integer id;
    String username;
    …
}
```

```
class Section {

    Integer id;
    Set<User> instructors;
    …
}
```

- *Database tables??*

… Join in HQL

- Query: find all the sections for which "cysun" is one of the instructors
  - *SQL??*
  - *HQL??*

SchemaExport

- Part of the Hibernate Core library
- Generate DDL from Java classes and annotations
- In CSNS2 and Hibernate Examples, run `Hbm2ddl <output_file>`

Basic Object-Relational Mapping

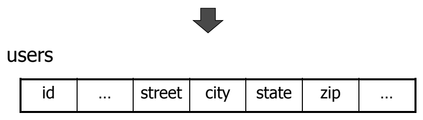
- Class-level annotations
  - @Entity and @Table
- Id field
  - @Id and @GeneratedValue
- Fields of simple types
  - @Basic (can be omitted) and @Column
- Fields of class types
  - @ManyToOne and @OneToOne

Advanced ORM

- Embedded class
- Collections
- Inheritance

Embedded Class

```
public class Address {          public class User {
    String street;                  Integer id;
    String city;                    String username
    String state;                   String password;
    String zip;                     Address address;
}                               }
```


users

id	...	street	city	state	zip	...

Mapping Embedded Class

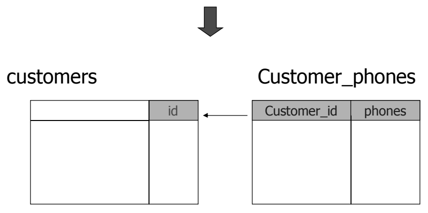
```
@Embeddable                     @Entity
public class Address {          public class User {
    String street;                  @Id
    String city;                    Integer id;
    String state;                   String username
    String zip;                     String password;
}                                   @Embedded
                                    Address address;
                                }
```

Collection of Simple Types

```
public class Customer {

        Integer id;

        String name;
        String address;

        Set<String> phones;

}
```

Mapping Element Collection

```
@ElementCollection
Set<String> phones;
```



Customize Collection Table

```
@ElementCollection
@CollectionTable(
    name = "customer_phones",
    joinColumns=@JoinColumn(name = "customer_id")
)
@Column(name="phone")
Set<String> phones;
```

List of Simple Types

- Order by property
  - @OrderBy("<property_name> ASC|DESC")
  - Simple types do not have properties

```
@ElementCollection
@OrderBy("asc")
List<String> phones;
```

- Order by a separate column

```
@ElementCollection
@OrderColumn(name = "phone_order")
List<String> phones;
```

Issues Related to Collections of Object Types

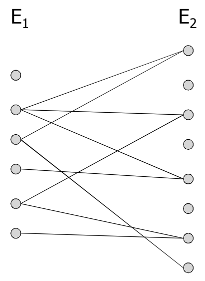
- Relationships (a.k.a. associations)
  - one-to-many
  - many-to-many
- Unidirectional vs. Bidirectional
- Set and List
- Cascading behaviors

Types of Relationships

- Many-to-Many
- Many-to-One / One-to-Many
- One-to-One

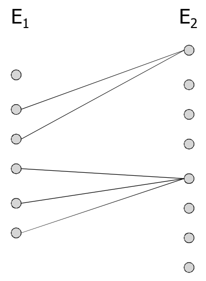
Many-to-Many Relationship

- Each entity in E_1 can be related to many entities in E_2
- Each entity in E_2 can be related to many entities in E_1



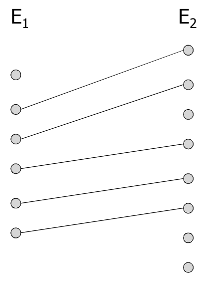
Many-to-One Relationship

- Each entity in E_1 can be related to one entities in E_2
- Each entity in E_2 can be related to many entities in E_1



One-to-One Relationship

- Each entity in E_1 can be related to one entities in E_2
- Each entity in E_2 can be related to one entities in E_1



Relationship Type Examples

- Books and authors??
- Books and editors??

One-To-Many Example

- A customer may own multiple accounts
- An account only has one owner

Bidirectional Association – OO Design #1

```
public class Account {

        Integer id;

        Double balance;
        Date createdOn;

        Customer owner;

}
```

```
public class Customer {

        Integer id;

        String name;
        String address;
        Set<String> phones;

        Set<Account> accounts;

}
```

Unidirectional Association – OO Design #2

```
public class Account {

        Integer id;

        Double balance;
        Date createdOn;

}
```

```
public class Customer {

        Integer id;

        String name;
        String address;
        Set<String> phones;

        Set<Account> accounts;

}
```

Unidirectional Association – OO Design #3

```
public class Account {

        Integer id;

        Double balance;
        Date createdOn;

        Customer owner;

}
```

```
public class Customer {

        Integer id;

        String name;
        String address;
        Set<String> phones;

}
```

Unidirectional vs. Bidirectional

- Do the three OO designs result in different database schemas??
- Does it make any difference on the application side??
- Which one should we use??

Mapping Bidirectional One-To-Many

```
public class Account {

    Integer id;

    Double balance;
    Date createdOn;

    @ManyToOne
    Customer owner;

}
```

```
public class Customer {

    Integer id;

    String name;
    String address;
    Set<String> phones;

    @OneToMany(mappedBy="owner")
    Set<Account> accounts;

}
```

property

Using List

```
public class Customer {

    Integer id;

    String name;
    String address;
    Set<String> phones;

    @OneToMany(mappedBy="owner")
    @OrderBy( "createdOn asc" )
    List<Account> accounts;

}
```

Many-To-Many Example

- A customer may own multiple accounts
- An account may have multiple owners

Mapping Many-To-Many

```
public class Account {

    Integer id;

    Double balance;
    Date createdOn;

    @ManyToMany
    Set<Customer> owners;

}
```

```
public class Customer {

    Integer id;

    String name;
    String address;
    Set<String> phones;

    @ManyToMany(mappedBy="owners")
    Set<Account> accounts;

}
```

Customize Join Table

```
@ManyToMany
@JoinTable(
    name = "account_owners",
    joinColumns=@JoinColumn(name = "account_id"),
    inverseJoinColumns=@JoinColumn(name="owner_id")
)
Set<Customer> owners;
```

Cascading Behavior

- Whether an operation on the parent object (e.g. Customer) should be applied to the children objects in a collection (e.g. List<Account>)

```
Customer c = new Customer("cysun");
Account a1 = new Account();
Account a2 = new Account();
c.getAccounts().add( a1 );
c.getAccounts().add( a2 );

entityManager.persist(c);    // will a1 and a2 be saved as well?
entityManager.remove(c);     // will a1 and a2 be deleted from db??
```

Cascading Types in JPA

- http://sun.calstatela.edu/~cysun/documentation/jpa-2.0-api/javax/persistence/CascadeType.html

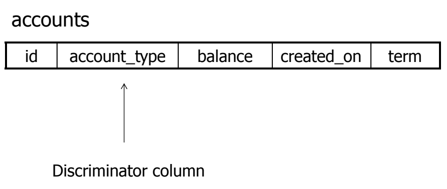
CascadeType Examples

```
@OneToMany(mappedBy="owner",
        cascade=CascadeType.PERSIST)
List<Account> accounts;

@OneToMany(mappedBy="owner",
        cascade={CascadeType.PERSIST, CascadeType.MERGE})
List<Account> accounts;

@OneToMany(mappedBy="owner",
        cascade=CascadeType.ALL)
List<Account> accounts;
```

Inheritance

```
public class CDAccount extends Account {

        Integer term;

}
```

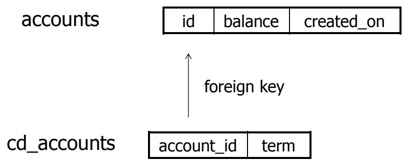
Everything in One Table



Inheritance Type – SINGLE_TABLE

```
@Entity
@Table(name="accounts")
@Inheritance(strategy=InheritanceType.SINGLE_TABLE)
@DiscriminatorColumn(name="account_type")
@DiscrimnatorValue("CHECKING")
public class Account { … }

@Entity
@DiscrimnatorValue("CD")
public class CDAccount { … }
```

Table Per Subclass



Inheritance Type – JOINED

```
@Entity
@Table(name="accounts")
@Inheritance(strategy=InheritanceType.JOINED)
public class Account { … }

@Entity
@Table(name="cd_accounts")
public class CDAccount { … }
```

Table Per Concrete Class

accounts

id	balance	created_on

cd_accounts

id	balance	created_on	term

Inheritance Type – TABLE_PER_CLASS

```
@Entity
@Table(name="accounts")
@Inheritance(strategy=InheritanceType.TABLE_PER_CLASS)
public class Account { … }

@Entity
@Table(name="cd_accounts")
public class CDAccount { … }
```

Tips for Hibernate Mapping

- Understand relational design
  - Know what the database schema should looks like before doing the mapping
- Understand OO design
  - Make sure the application design is object-oriented

Further Readings

- TopLink JPA Annotation Reference – http://www.oracle.com/technetwork/middleware/ias/toplink-jpa-annotations-096251.html
- *Pro JPA 2* by Mike Keith and Merrick Schincariol