CS520 Web Programming
Object-Relational Mapping with Hibernate

Chengyu Sun
California State University, Los Angeles

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), e.g. *accounts*, *customers*, *employees*
- 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

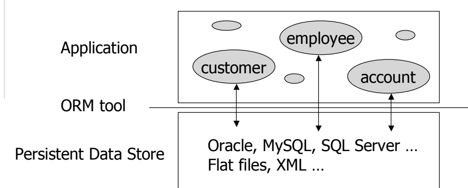
```
public Employee( Integer id ) {
    …
    ResultSet rs = p.executeQuery();
    if( rs.next() )
    {
        …
        supervisor = ??
    }
}
```

The ORM Approach

Application

ORM tool

Persistent Data Store



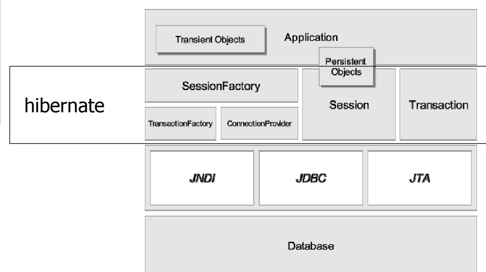
Advantages of ORM

- 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

Common ORM Tools

- Java Data Object (JDO)
  - One of the Java specifications
  - Flexible persistence options: RDBMS, OODBMS, files etc.
- Hibernate
  - Most popular Java ORM tool right now
  - Persistence by RDBMS only
- Others
  - http://en.wikipedia.org/wiki/Object-relational_mapping
  - http://www.theserverside.net/news/thread.tss?thread_id=29914

Hibernate Application Architecture



Setup Hibernate

- Download *Hibernate Core* from http://www.hibernate.org
- Add the following jar files to CLASSPATH
  - *hibernate-3.1\hibernate3.jar*
  - All the jar files under *hibernate-3.1\lib*
  - The JDBC driver of your DBMS

A Simple Hibernate Application

- Java classes
  - `Employee.java`
- O/R Mapping files
  - `Employee.hbm.xml`
- Hibernate configuration file
  - `hibernate.cfg.xml`
- (Optional) Logging configuration files
  - `Log4j.properties`
- Code to access the persistent objects
  - `EmployeeTest1.java`

Java Classes

- Plain Java classes (POJOs); however, it is *recommended* that
  - Each persistent class have an identity field
  - Each persistent field have a pair of getter and setter, *which don't have to be public*
- The identity field is used to uniquely identify an object
- The persistent fields are accessed as bean *properties*

O/R Mapping Files

- Describe how class fields are mapped to table columns
- Three important types of elements in a a mapping file
  - <id>
  - <property> - when the field is of simple type
  - Association – when the field is of a class type
    - <one-to-one>
    - <many-to-one>
    - <many-to-many>

Hibernate Configuration Files

- Tell hibernate about the DBMS and other configuration parameters
- Either hibernate.properties or hibernate.cfg.xml or both
  - Sample files under *hibernate-3.1/etc*

Logging

- Use print statements to assist debugging
  - Why do we want to do that when we have GUI debugger??

```
public void foo()
{
   System.out.println( "loop started" );
   // some code that might get into infinite loop
   …
   System.out.println( "loop finished" );
}
```

Requirements of Good Logging Tools

- Minimize performance penalty
- Support different log output
  - Console, file, database, …
- Support different message levels
  - Fatal, error, warn, info, debug, trace
- Easy configuration

Log4j and Commons-logging

- Log4j
  - A logging tool for Java
  - http://logging.apache.org/log4j/docs/
- Commons-logging
  - A wrapper around different logging implementations to provide a consistent API
  - http://jakarta.apache.org/commons/logging/

Log4j Configuration File

- log4j.properties specifies
  - Output type
  - Output format
  - Class
  - Message level

Output type, Output format } Appender

Class, Message level } Logger

Logging Examples

- hex.test.LogTest
- Textbook: Chapter 9

Access Persistent Objects

- `Session`
- `Query`
- `Transaction`
  - A transaction is required for updates

Hibernate Query Language (HQL)

- 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

CRUD Example

- EmployeeTest2.java
  - "from Employee"
  - load() or get()?
  - How does hibernate tell whether an object is new??
  - Caching

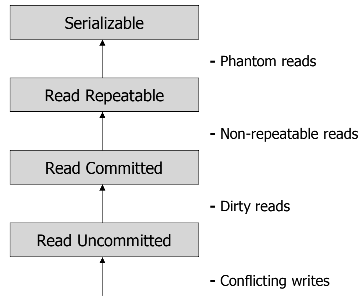
load() vs. get()

- `load()` raises an exception if an object cannot be found; `get()` would return null
- `load()` may return a proxy but `get()` never does

Caching

- Object cache and query cache
- Cache scopes
  - Session
  - Process
  - Cluster

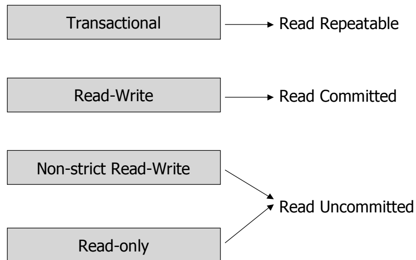
Transaction Isolation Levels



Caching in Hibernate

- First-level cache
  - Session scope
  - Always on (and cannot be turned off)
- Second-level cache
  - Pluggable *Cache Providers*
  - Process cache
    - EHCache and OSCache
  - Cluster cache
    - SwarmCache and JBossCache

Hibernate Cache Concurrency Policies



Currency Support of Hibernate Cache Providers

	Read-only	Non-strict Read-Write	Read-Write	Transactional
EHCache	X	X	X	
OSCache	X	X	X	
SwarmCache	X	X		
JBossCache	X			X

hbm2ddl

- Generate DDL statements from Java classes and mapping files
- `db/`
  - `hex.ddl` – generated automatically by hbm2ddl
  - `hex.sql` – based on hex.ddl but maintained manually

More About Mapping

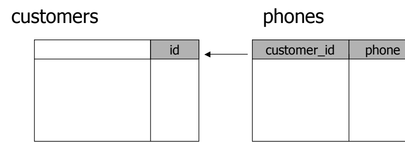
- Basic mapping
  - <id>
  - <property>
  - Association
    - many-to-one
    - one-to-many
    - one-to-one
    - many-to-many
- Collections
- Subclasses
- Components
- Other
  - Bidirectional association
  - Multi-way relationship

Collection of Simple Types

```
public class Customer {

        Integer id;

        String name;
        String address;

        Set<String> phones;

}
```

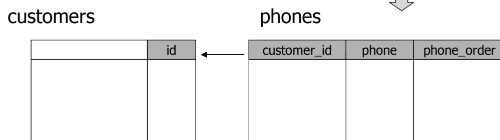
Map Set of Simple Types

```
<set name="phones" table="phones" lazy="true">
     <key column="customer_id"/>
     <element type="string" column="phone"/>
</set>
```



Map List of Simple Types

```
<list name="phones" table="phones" lazy="true">
     <key column="customer_id"/>
     <index column="phone_order"/>
     <element type="string" column="phone"/>
</list>
```

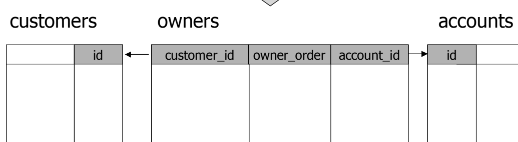


Collection of Object Types

```
public class Account {

        Integer id;

        BigDecimal balance;
        Date createdOn;

        List<Customer> owners;

}
```

Map List of Object Types

```
<list name="owners" table="owners" lazy="true">
     <key column="account_id"/>
     <index column="owner_order"/>
     <many-to-many class="Customer" column="customer_id"/>
</list>
```



Inheritance

```
public class CDAccount extends Account {

        Integer term;

}
```

- When do we want to create subclasses??

Map Subclass – Table Per Concrete Class

accounts

id	balance	created_on

cd_accounts

id	balance	created_on	term

Map Subclasses – Table Per Subclass

```
<joined-subclass name="CDAccount" table="cd_accounts">
    <key column="account_id"/>
    <property name="term"/>
</joined-subclass>
```

cd_accounts

id	term

accounts

id	balance	created_on

Map Subclasses – Table Per Hierarchy

```
<discriminator column="account_type" type="string"/>

<subclass name="CDAccount" discriminator-value="CD">
    <property name="term"/>
</subclass>
```

accounts

id	balance	created_on	term

Components

```
public class Address {
        String street, city, state, zip;
}

public class User {
        Integer id;

        String username, password;
        Address address;
}
```

Map Components

```
<component  name="address" class="Address">
    <property name="street"/>
    <property name="city"/>
    <property name="state"/>
    <property name="zip"/>
</component>
```

users

id	...	street	city	state	zip	...

Components Inside Collection

```
<list name="history" table="bibtex_history" lazy="true">

    <key column="bibtex_id" />
    <index column="bibtex_order" />

    <composite-element class="BibtexEntry">
        <property name="content" />
        <many-to-one name="editor" class="User" />
        <property name="lastModified" column="last_modified" />
    </composite-element>

</list>
```

Somewhat Unusual Mappings

- Bidirectional Association
  - Accounts and Owners
  - Item vs. Reviews, Ratings, and Tags
- Multi-way relationship
  - Tag

O/R Mapping vs. ER-Relational Conversion

O/R Mapping		ER-Relational Conversion
Class	←→	Entity Set
<property>	←→	Attribute
Association	←→	Relationship
Subclass		Subclass
• table per concrete class	←→	• OO method
• table per class hierarchy	←→	• NULL method
• table per subclass	←→	• ER method

Things We'll Talk Later (Or Not)

- Fine tune the schema
  - not-null, unique etc.
- Performance-related issues
  - Lazy-loading
- More about queries
  - Criteria queries
  - Native SQL queries

Conclusion?

- What does hibernate give us??

More Hibernate Resource

- Textbook: Chapter 5
- *Hibernate in Action* by Christian Bauer and Gavin King
- Hibernate documentation at http://www.hibernate.org
  - Chapter 6-10

More Readings

- *Database Systems – The Complete Book* by Garcia-Molina, Ullman, and Widom
  - Chapter 2: ER Model
  - Chapter 3.2-3.3: ER to Relational Conversion
  - Chapter 4.1-4.4: OO Concepts in Databases
  - Chapter 9: OQL
  - Chapter 8.7: Transactions