Java Persistence API (JPA)

Based on the slides of Mike Keith, Oracle Corp.

About JPA

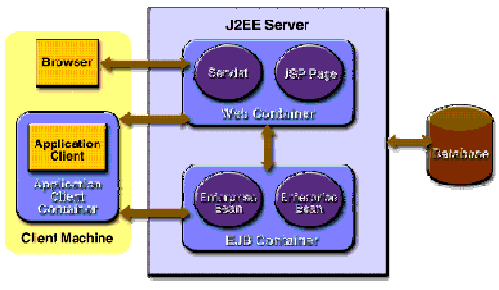
- Persistence API for operating on Plain Old Java Objects (POJO).
- Merger of expertise from TopLink, Hibernate, JDO, EJB vendors and individuals
- Created as part of EJB 3.0 within JSR 220
- Released May 2006 as part of Java EE 5
- Integration with Java EE web and EJB containers provides enterprise “ease of use” features
- “Bootstrap API” can also be used in Java SE
- Pluggable Container-Provider SPI

Reference Implementation

- Part of "Glassfish" project on java.net
  - RI for entire Java EE platform
- Sun and Oracle partnership
  - Sun Application Server + Oracle persistence
- JPA impl called "TopLink Essentials"
  - Donated by Oracle, derived from Oracle TopLink
- All open source (under CDDL license)
  - Anyone can download/use source code or binary code in development or production

Java EE application model

- Java EE is a multitiered distributed application model
  - client machines
  - the Java EE server machine
  - the database or legacy machines at the back end



Anatomy of an Entity

- Abstract or concrete top level Java class
  - Non-`final` fields/properties, no-arg constructor
- No required interfaces
  - No required business or callback interfaces (but you may use them if you want to)
- Direct field or property-based access
  - Getter/setter can contain logic (e.g. for validation)
- May be Serializable, but not required
  - Only needed if passed by value (in a remote call)

The Minimal Entity

- Must be indicated as an Entity

1. @Entity annotation on the class

```
@Entity
public class Employee { … }
```

2. Entity entry in XML mapping file

```
<entity class="com.acme.Employee"/>
```

The Minimal Entity

- Must have a persistent identifier (primary key)

```
@Entity
public class Employee {
   @Id int id;

   public int getId() { return id; }
   public void setId(int id) { this.id = id; }
}
```

Persistent Identity

- Identifier (id) in entity, primary key in database
- Uniquely identifies entity in memory and in db

1. Simple id – single field/property
   ```
   @Id int id;
   ```
2. Compound id – multiple fields/properties
   ```
   @Id int id;
   @Id String name;
   ```
3. Embedded id – single field of PK class type
   ```
   @EmbeddedId EmployeePK id;
   ```

Uses PK class

Identifier Generation

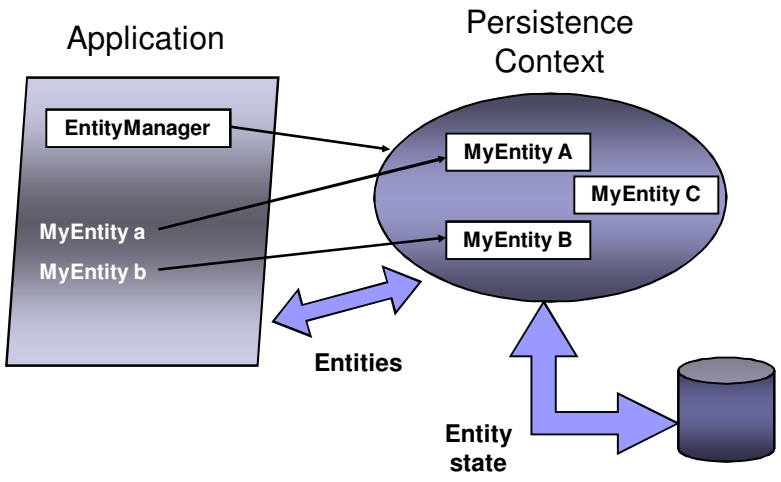
- Identifiers can be generated in the database by specifying @GeneratedValue on the identifier

```
@Id @GeneratedValue
int id;
```

Persistence Context

- Abstraction representing a set of "managed" entity instances
  - Entities keyed by their persistent identity
  - Only one entity with a given persistent identity may exist in the PC
- Controlled and managed by EntityManager
  - Contents of PC change as a result of operations on EntityManager API

Persistence Context



Entity Manager

- Client-visible artifact for operating on entities
  - API for all the basic persistence operations
- Can think of it as a proxy to a persistence context
  - May access multiple different persistence contexts throughout its lifetime

Operations on Entities

- EntityManager API
  - `persist()` - Insert the state of an entity into the db
  - `remove()` - Delete the entity state from the db
  - `refresh()` - Reload the entity state from the db
  - `merge()` - Synchronize the state of detached entity with the pc
  - `find()` - Execute a simple PK query
  - `createQuery()` - Create query instance using dynamic JP QL
  - `createNamedQuery()` - Create instance for a predefined query
  - `createNativeQuery()` - Create instance for an SQL query
  - `contains()` - Determine if entity is managed by pc
  - `flush()` - Force synchronization of pc to database

persist()

- Insert a new entity instance into the database
- Save the persistent state of the entity and any owned relationship references
- Entity instance becomes managed

```
public Customer createCustomer(int id, String name) {
    Customer cust = new Customer(id, name);
    entityManager.persist(cust);
    return cust;
}
```

find() and remove()

- find()
  - Obtain a managed entity instance with a given persistent identity – return null if not found
- remove()
  - Delete a managed entity with the given persistent identity from the database

```
public void removeCustomer(Long custId) {
    Customer cust =
        entityManager.find(Customer.class, custId);
    entityManager.remove(cust);
}
```

Queries

- Dynamic or statically defined (named queries)
- Criteria using JP QL (extension of EJB QL)
- Native SQL support (when required)
- Named parameters bound at execution time
- Pagination and ability to restrict size of result
- Single/multiple-entity results, data projections
- Bulk update and delete operation on an entity
- Standard hooks for vendor-specific hints

Queries

- Query instances are obtained from factory methods on EntityManager
- Query API:

`getResultList()` – execute query returning multiple results
`getSingleResult()` – execute query returning single result
`executeUpdate()` – execute bulk update or delete
`setFirstResult()` – set the first result to retrieve
`setMaxResults()` – set the maximum number of results to retrieve
`setParameter()` – bind a value to a named or positional parameter
`setHint()` – apply a vendor-specific hint to the query
`setFlushMode()` – apply a flush mode to the query when it gets run

Dynamic Queries

- Use createQuery() factory method at runtime and pass in the JP QL query string
- Use correct execution method
  - getResultList(), getSingleResult(), executeUpdate()
- Query may be compiled/checked at creation time or when executed
- Maximal flexibility for query definition and execution

Dynamic Queries

```
public List findAll(String entityName){
    return entityManager.createQuery(
      "select e from " + entityName + " e")
        .setMaxResults(100)
        .getResultList();
}
```

- Return all instances of the given entity type
- JP QL string composed from entity type. For example, if “Account” was passed in then JP QL string would be: “**select e from Account e**”

Named Queries

- Use createNamedQuery() factory method at runtime and pass in the query name
- Query must have already been statically defined either in an annotation or XML
- Query names are “globally” scoped
- Provider has opportunity to precompile the queries and return errors at deployment time
- Can include parameters and hints in static query definition

Named Queries

```
@NamedQuery(name="Sale.findByCustId",
    query="select s from Sale s
           where s.customer.id = :custId
           order by s.salesDate")

public List findSalesByCustomer(Customer cust) {
  return
    entityManager.createNamedQuery(
                          "Sale.findByCustId")
         .setParameter("custId", cust.getId())
         .getResultList();
}
```

- Return all sales for a given customer

Object/Relational Mapping

- Map persistent object state to relational database
- Map relationships to other entities
- Metadata may be annotations or XML (or both)
- Annotations
  - Logical—object model (e.g. @OneToMany)
  - Physical—DB tables and columns (e.g. @Table)
- XML
  - Can additionally specify scoped settings or defaults
- Standard rules for default db table/column names

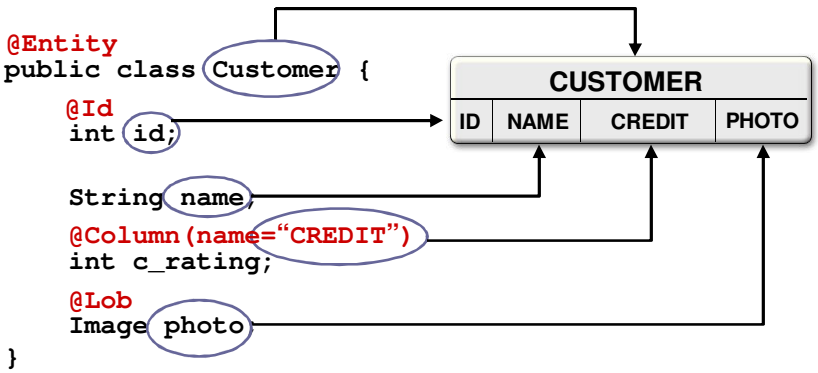
Object/Relational Mapping

- State or relationships may be loaded or “fetched” as EAGER or LAZY
  - LAZY - hint to the Container to defer loading until the field or property is accessed
  - EAGER - requires that the field or relationship be loaded when the referencing entity is loaded
- Cascading of entity operations to related entities
  - Setting may be defined per relationship
  - Configurable globally in mapping file for persistence-by-reachability

Simple Mappings

- Direct mappings of fields/properties to columns
  - @Basic - optional annotation to indicate simple mapped attribute
- Maps any of the common simple Java types
  - Primitives, wrappers, enumerated, serializable, etc.
- Used in conjunction with @Column
- Defaults to the type deemed most appropriate if no mapping annotation is present
- Can override any of the defaults

Simple Mappings



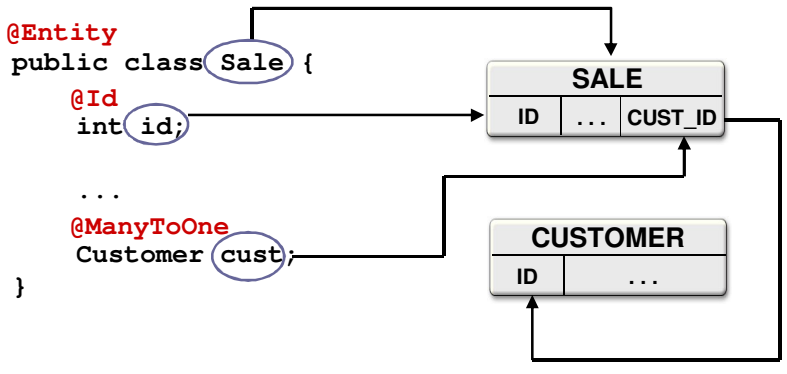
Simple Mappings

```
<entity class="com.acme.Customer">
  <attributes>
    <id name="id"/>
    <basic name="c_rating">
      <column name="CREDIT"/>
    </basic>
    <basic name="photo"><lob/></basic>
  </attributes>
</entity>
```

Relationship Mappings

- Common relationship mappings supported
  - @ManyToOne, @OneToOne—single entity
  - @OneToMany, @ManyToMany—collection of entities
- Unidirectional or bidirectional
- Owning and inverse sides of every bidirectional relationship
- Owning side specifies the physical mapping
  - @JoinColumn to specify foreign key column

ManyToOne Mapping

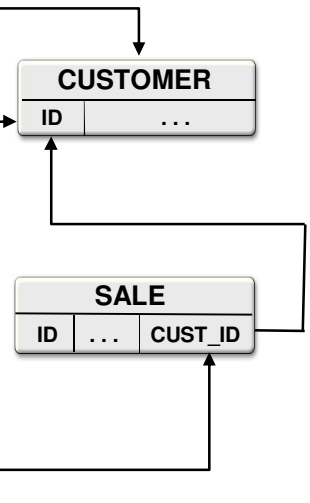


ManyToOne Mapping

```
<entity class="com.acme.Sale">
  <attributes>
    <id name="id"/>
    ...
    <many-to-one name="cust"/>
  </attributes>
</entity>
```

OneToMany Mapping

```
@Entity
public class Customer {
  @Id
  int id;
  ...
  @OneToMany(mappedBy="cust")
  Set<Sale> sales;
}
@Entity
public class Sale {
  @Id
  int id;
  ...
  @ManyToOne
  Customer cust;
}
```



OneToMany Mapping

```
<entity class="com.acme.Customer">
  <attributes>
    <id name="id"/>
      ...
    <one-to-many name="sales" mapped-by="cust"/>
  </attributes>
</entity>
```

Persistence in Java SE

- No deployment phase
  - Application must use a "Bootstrap API" to obtain an EntityManagerFactory
- Resource-local EntityManagers
  - Application uses a local EntityTransaction obtained from the EntityManager
- New application-managed persistence context for each and every EntityManager
  - No propagation of persistence contexts

Entity Transactions

- Only used by Resource-local EntityManagers
- Isolated from transactions in other EntityManagers
- Transaction demarcation under explicit application control using EntityTransaction API
  - begin(), commit(), rollback(), isActive()
- Underlying (JDBC) resources allocated by EntityManager as required

Bootstrap Classes

`javax.persistence.Persistence`

- Root class for bootstrapping an EntityManager
- Locates provider service for a named persistence unit
- Invokes on the provider to obtain an EntityManagerFactory

`javax.persistence.EntityManagerFactory`

- Creates EntityManagers for a named persistence unit or configuration

Example

```
public class PersistenceProgram {
  public static void main(String[] args) {
    EntityManagerFactory emf = Persistence
        .createEntityManagerFactory("SomePUnit");
    EntityManager em = emf.createEntityManager();
    em.getTransaction().begin();
    // Perform finds, execute queries,
    // update entities, etc.
    em.getTransaction().commit();
    em.close();
    emf.close();
  }
}
```

JSF Example:

```
20   * @author ala
21   */
22  @ManagedBean(name = "studentList")
23  @SessionScoped
24  @TransactionManagement(TransactionManagementType.BEAN)
25  public class StudentList {
26
27      @PersistenceContext
28      private EntityManager em;
29      @Resource
30      private UserTransaction utx;
31
32      public StudentList() {
33      }
34      private String lName;
35
36      /**
37       * Get the value of lName
38       *
```

JPA Insert Example

```
Students st = new Students();
st.setFirstname(fName);
st.setLastname(lName);
st.setEmail(email);
st.setSsn(new BigDecimal(ssn));
try {
    utx.begin();
    em.persist(st);
    utx.commit();
} catch (Exception e) {
}
```

JPA Find and Delete Examples

```
try {
    utx.begin();

    Students one = (Students) em.find(Students.class, new BigDecimal(st.getSsn()));

    em.remove(one);
    utx.commit();
} catch (Exception e) {
}
```

JPA NamedQuery Examples

```
List<Students> dbl = em.createNamedQuery("Students.findAll").getResultList();

list = new ArrayList<Student>();

for (Students s : dbl) {
    Student one = new Student();
    one.setFirstName(s.getFirstname());
    one.setLastName(s.getLastname());
    one.setEmail(s.getEmail());
    one.setSsn(s.getSsn().intValue());

    list.add(one);
}
```

JPA NamedQuery Examples

```
@NamedQuery(name="Pet.findByName",
   query="SELECT p FROM Pet p WHERE p.name LIKE :pname")
@Entity
public class Pet {
   ...
}
```

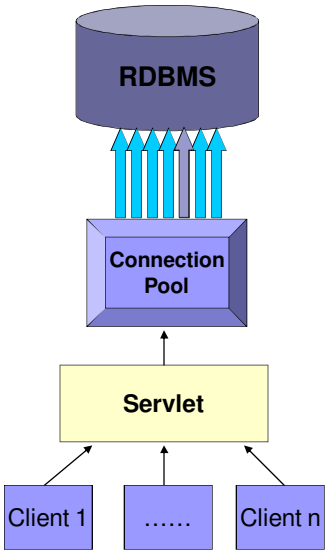
```
public List findAllPetsByName(String petName) {
   Query q = em.createNamedQuery("Pet.findByName");
   q.setParameter("pname", petName);
   return q.getResultList();
}
```

JPA Dynamic Query Example

```
Query q = em.createQuery("SELECT p FROM Pet p");
q.setMaxResults(100);
List results = q.getResultList();
```

Database Connection Pooling

- Connection pooling is a technique that was pioneered by database vendors to allow multiple clients to share a cached set of connection objects that provide access to a database resource
- Connection pools minimize the opening and closing of connections



JPA Configuration

JPA configuration needed to get your application up and running. It is based on the notion of a persistence unit, and is configured in a file called **persistence.xml**, which must always be placed in the META-INF directory of your deployment unit. Each persistence unit is a configuration closure over the settings necessary to run in the relevant environment. The parent element in a persistence.xml file is the persistence element and may contain one or more **persistence-unit** elements representing different execution configurations. Each one must be named using the mandatory persistence-unit name attribute.

JPA Configuration

- In a managed container the target database is indicated through the **jta-data-source** element, which is the **JNDI** name for the managed data source describing where the entity state is stored for that configuration unit

```
<persistence-unit name="PetShop">
   <jta-data-source>jdbc/PetShopDB</jta-data-source>
</persistence-unit>
```

Summary

- ✓ JPA emerged from best practices of existing best of breed ORM products
- ✓ Lightweight persistent POJOs, no extra baggage
- ✓ Simple, compact and powerful API
- ✓ Standardized object-relational mapping metadata specified using annotations or XML
- ✓ Feature-rich query language
- ✓ Java EE integration, additional API for Java SE
- ✓ “Industrial strength” Reference Implementation