Advanced Java Programming Course

# Java Persistence API

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# Session objectives

- Introduction to Java Persistence API
- ORM – Object/Relational Mapper
  - Entities
  - EntityManager & the Persistent Context
  - Persistence Units
  - Exceptions
  - Java Persistence Query Language
- OGM – Object/Grid Mapper
  - Introduction
  - OGM for MongoDb

# Introduction

# Introduction

- Previously we learnt about
  - JDBC
  - Data Access Objects (DAO) and Data Transfer Objects (DTO)

1. In JDBC, we "hard coded" SQL into our application
2. Then used Data Source/Connection Pooling
3. Then used DAO/DTO
4. But this just "hides" implementation from our business logic, you still implement DAO with JDBC

# Issues not solved

- However,
  - We still have to understand a lot of implementation details (eg: connections, statements, resultsets etc)
  - What about relationships? Joins? Inheritance?
  - Object database impedance mismatch
- J2EE tried to solve this with "Entity Enterprise JavaBeans (EJB)"
  - Simpler alternatives included

    Object Relational Mapping (ORM) tools:
  - e.g. Java Data Objects (JDO), Hibernate, iBatis, TopLink

# Notes: Object Relational Mismatch

- Object Relational Mismatch
  - SQL Types and Java Types are different
    - Databases also support SQL types differently
    - Tend to define their own internal data types e.g. Oracle's NUMBER type
    - Types must be mapped between Java and SQL/Database
    - JDBC (Generic SQL) Types are defined in java.sql.Types
    - java types are very rich; SQL types are more restrictive
  - How to map class to table? 1:1? 1:n?
  - How to map columns to class properties?
  - BLOB support? Streaming?
  - How to do Object Oriented design here? What about inheritance? Abstraction? Re-use?

# Java EE 5 to the rescue

- Java SE 5 added new constructs to Java language
  - Generics
  - Annotations
  - Enumerations
- Java EE 5 used these features to provide
  - Ease of development
  - "Dependency injection"
  - Meaningful defaults, "code by exception"
  - Simplified EJB
  - New Java Persistence API (JPA) replaced Entity EJB
- JPA can also be used in Java SE 5 without a container

# About JPA

- What is Java Persistence API (JPA)?
  - Database persistence technology for Java
    - Object-relational mapping (ORM) engine
    - Operates with POJO entities
    - Similar to Hibernate and JDO
  - JPA maps Java classes to database tables
    - Maps relationships between tables as associations between classes
  - Provides CRUD functionality
    - Create, read, update, delete

# History of JPA

- History of JPA
  - Created as part of EJB 3.0 within JSR 220
  - Released May 2006 as part of Java EE 5
  - Can be used as standalone library
- Standard API with many implementations
  - OpenJPA – http://openjpa.apache.org/
  - Hibernate – http://www.hibernate.org
  - TopLink JPA – http://www.oracle.com/technology/jpa
  - JPOX – http://www.jpox.org/

# JPA implementation

- Reference implementation: TopLink (GlassFish project)
- Most ORM vendors now have JPA interface
  - Hibernate-JPA,
  - EclipseLink (based on TopLink),
  - OpenJPA (based on BEA Kodo)
- All open source (under CDDL license)
  - Anyone can download/use source code or binary code in development or production

# The Java Persistence API

## Entities

# Anatomy of an Entity

- An entity is a plain old java object (POJO)
- The Class represents a table in a relational database.
- Instances correspond to rows
- Requirements:
  - annotated with the javax.persistence.Entity annotation
  - public or protected, no-argument (parameterless) constructor
  - the class must not be declared final
  - no methods or persistent instance variables must be declared final

# Requirements for Entities

- May be Serializable, but not required
  - Only needed if passed by value (in a remote call)
- Entities may extend both entity and non-entity classes
- Non-entity classes may extend entity classes
- Persistent instance variables must be declared private, protected, or package-private (*default visibility*) modifier
- No required business/callback interfaces
- Example:

```
@Entity
class Person{
    . . .
}
```

# Persistent Fields and Properties

- The persistent state of an entity can be accessed:

  through the entity's instance variables

  through JavaBeans-style properties (getters/setters)

- Supported types:

  primitive types, String, other serializable types, enumerated types

  other entities and/or collections of entities

  embeddable classes

- All fields not annotated with `@Transient` or not marked as Java *transient* will be persisted to the data store!

# Primary Keys in Entities

- Each entity must have a unique object identifier (persistent identifier)

```
@Entity
public class Employee {
        @Id private int id;
        private String name;
        private Date age;

        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
- Persistent identity types:
  - Simple id – single field/property

    ```
    @Id int id;
    ```

  - Compound id – multiple fields/properties

    ```
    @Id int id;
    @Id String name;
    ```

  - Embedded id – single field of PK class type

    ```
    @EmbeddedId EmployeePK id;
    ```

# Identifier Generation

- Identifiers can be generated in the database by specifying @GeneratedValue on the identifier
- Four pre-defined generation strategies:

  AUTO, IDENTITY, SEQUENCE, TABLE
- Generators may pre-exist or be generated
- Specifying strategy of AUTO indicates that the provider will choose a strategy
- Example

```
@Id
@GeneratedValue(strategy=GenerationType.AUTO)
private int id;
```

# Customizing the Entity Object

- In most of the cases, the defaults are sufficient
- By default the table name corresponds to the unqualified name of the class
- Customization:

```
@Entity
@Table(name = "FULLTIME_EMPLOYEE")
public class Employee{ …… }
```

- The defaults of columns can be customized using the `@Column` annotation

```
@Id @Column(name = "EMPLOYEE_ID", nullable = false)
private String id;

@Column(name = "FULL_NAME" nullable = true, length = 100)
private String name;
```

# Entity Relationships

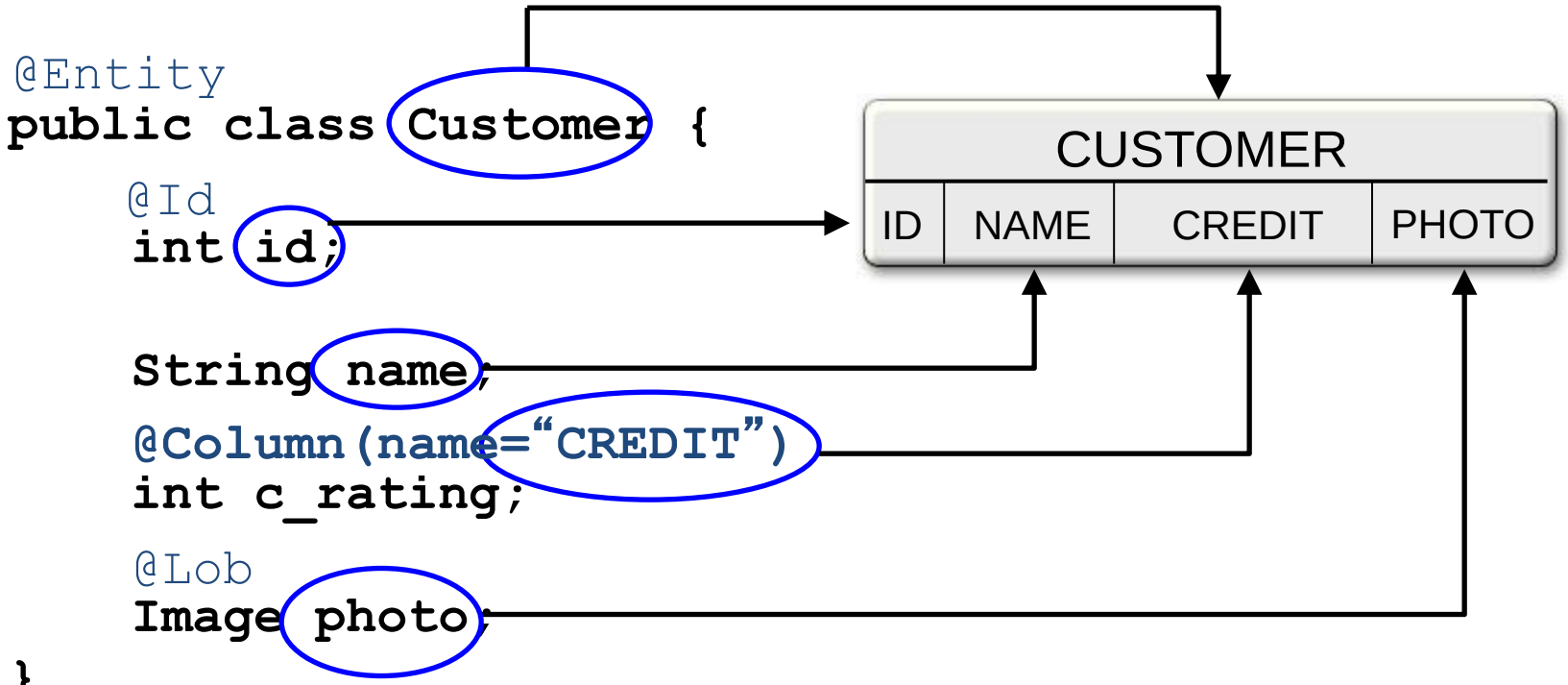
- There are four types of relationship multiplicities:
  - @OneToOne
  - @OneToMany
  - @ManyToOne
  - @ManyToMany
- The direction of a relationship can be:
  - bidirectional – owning side and inverse side
  - unidirectional – owning side only
- Owning side specifies the physical mapping

# Entity Relation Attributes

- JPA supports cascading updates/deletes
  - CascadeType
    - **ALL, PERSIST, MERGE, REMOVE, REFRESH**
- You can declare performance strategy to use with fetching related rows
  - FetchType
    - **LAZY, EAGER**
      - (Lazy means don't load row until the property is retrieved)

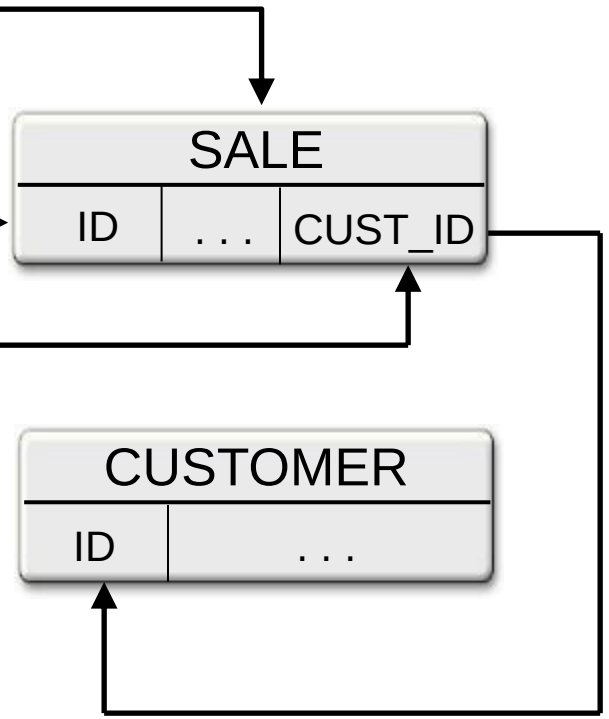
```
@ManyToMany(
cascade = {CascadeType.PERSIST, CascadeType.MERGE},
fetch = FetchType.EAGER)
```

# Simple Mappings



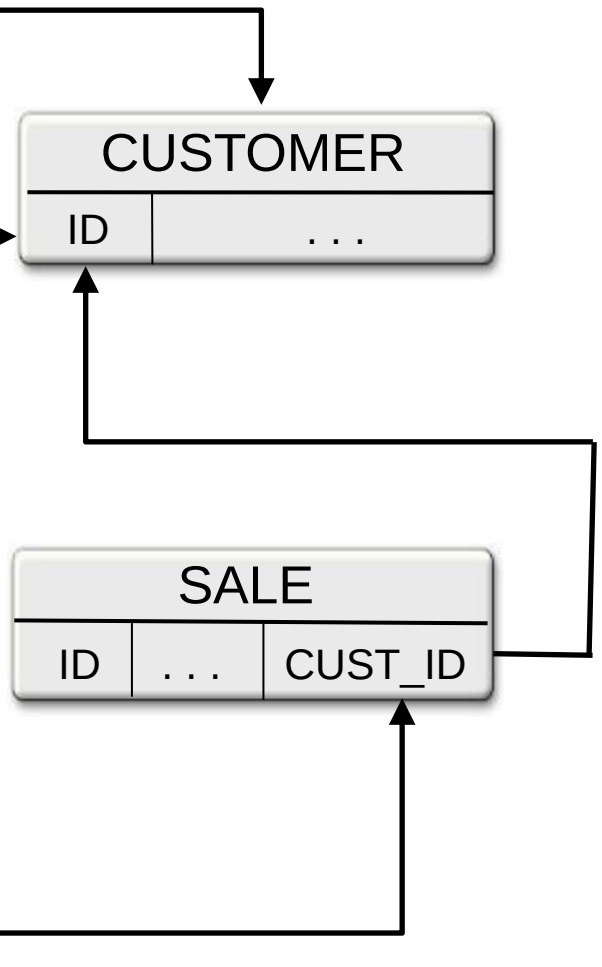
# ManyToOne Mapping

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

    ...

    @ManyToOne
    Customer cust;
}
```



# 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;
}
```



# ManyToMany Mapping

```
@Entity
public class Customer {
   ...
@ManyToMany(cascade=CascadeType.ALL)
@JoinTable(name="CUSTOMER_SALE",
        joinColumns=@JoinColumn(name="CUSTOMER_ID",
                referencedColumnName="customer_id"),
                inverseJoinColumns=@JoinColumn(
name="SALE_ID", referencesColumnName="sale_id")
  Collection<Sale> sales;
}

@Entity
public class Sale {
    ...
  @ManyToMany(mappedBy="sales")
  Collection<Customer> customers;
}
```

# Persistence Units

# Persistence Unit

- A persistence unit defines a **set** of all entity classes that are managed by EntityManager instances in an application
- Each persistence unit can have different providers and database drivers
- Persistence units are defined by the META-INF /persistence.xml configuration file

# The persistence.xml

- A persistence.xml file defines one or more persistence units

```
<persistence-unit name="TemporalConstraint">
    <provider>org.eclipse.persistence.jpa.PersistenceProvider</provider>
    <class>my.package.MyEntity</class>
    <exclude-unlisted-classes>false</exclude-unlisted-classes>
    <properties>
        <property name="eclipselink.target-database" value="SQLServer" />
        <property name="eclipselink.ddl-generation" value="none" />
        <property name="javax.persistence.jdbc.url"
            value="jdbc:sqlserver://localhost:1433;databaseName=MyDatabase"/>
        <property name="javax.persistence.jdbc.user" value="username"/>
        <property name="javax.persistence.jdbc.password" value="password"/>
        <property name="javax.persistence.jdbc.driver"
            value="com.microsoft.sqlserver.jdbc.SQLServerDriver"/>
    </properties>
</persistence-unit>
```

# EntityManager & the Persistent Context

Using Persistence API

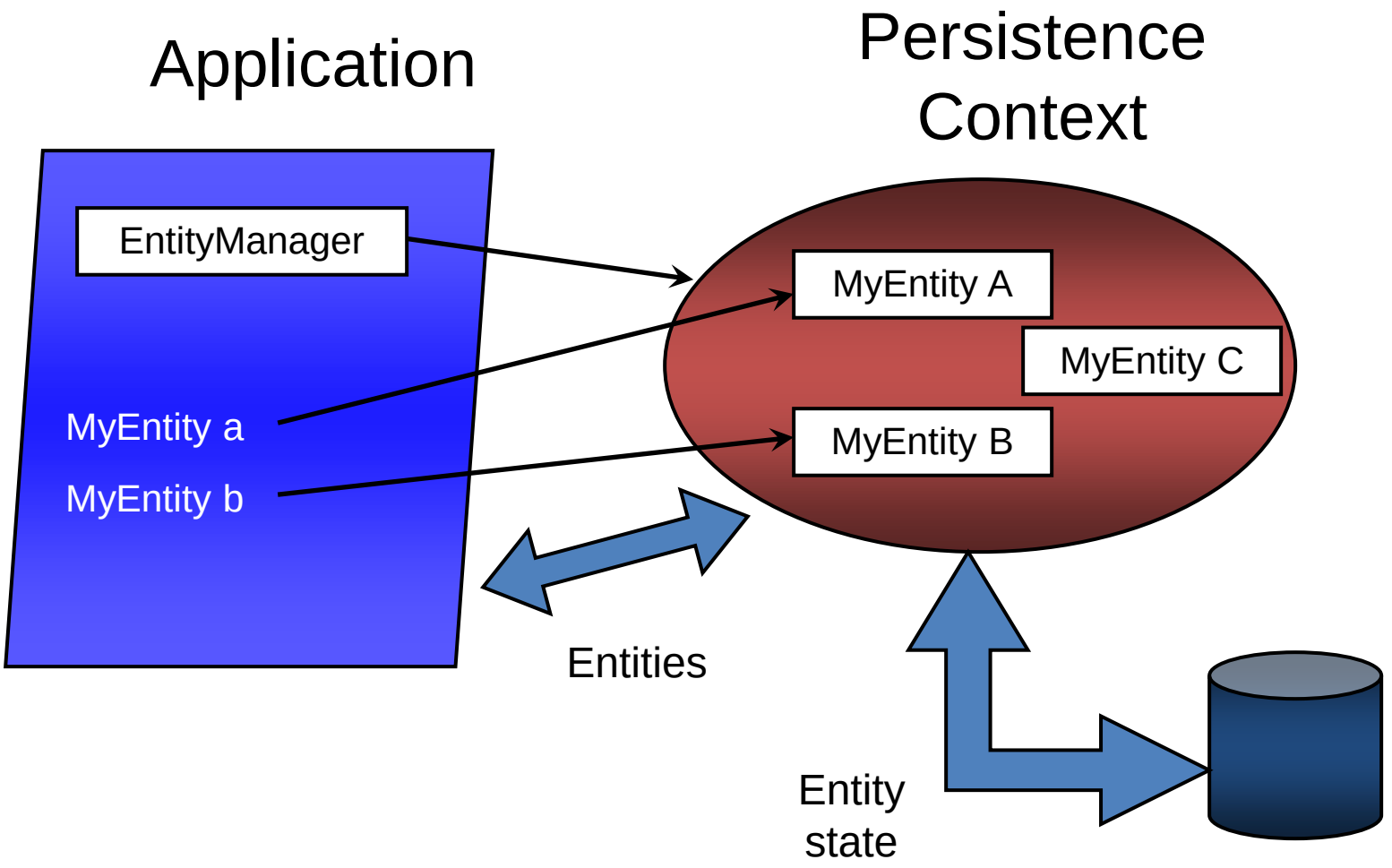
# Managing Entities

- Entities are managed by the entity manager
- The entity manager is represented by javax.persistence.EntityManager instances
- Each EntityManager instance is associated with a persistence context
- A persistence context defines the scope under which particular entity instances are created, persisted, and removed

# Persistence Context

- A persistence context is a set of managed entity instances that exist in a particular data store
  - Entities keyed by their persistent identity
  - Only one entity with a given persistent identity may exist in the persistence context
  - Entities are added to the persistence context, but are not individually removable ("detached")
- Controlled and managed by EntityManager
  - Contents of persistence context change as a result of operations on EntityManager API

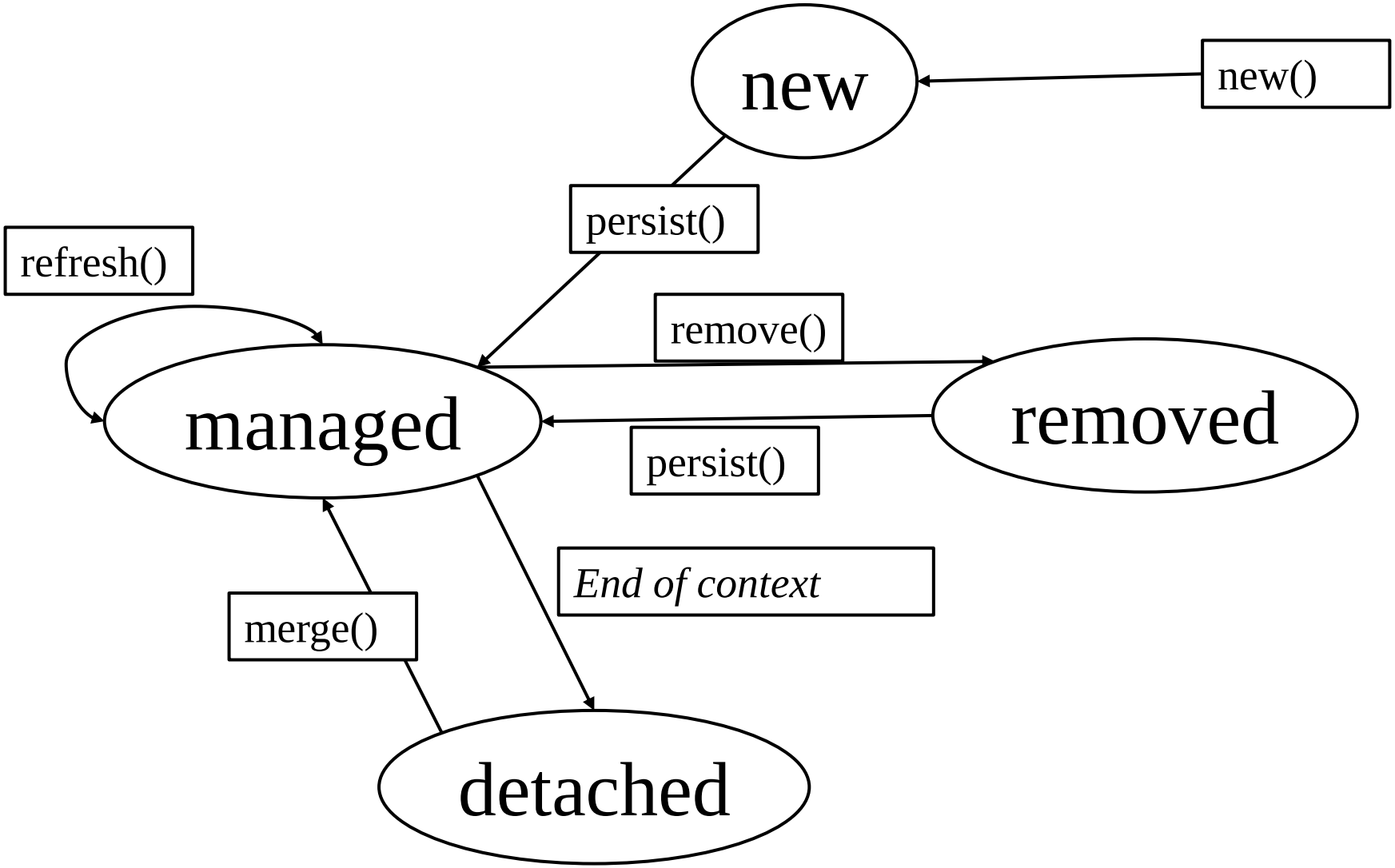
# Persistence Context



# Entity Manager

- An **`EntityManager`** instance is used to manage the state and life cycle of entities within a persistence context
- Entities can be in one of the following states:
  1. New
  2. Managed
  3. Detached
  4. Removed

# Entity Lifecycle

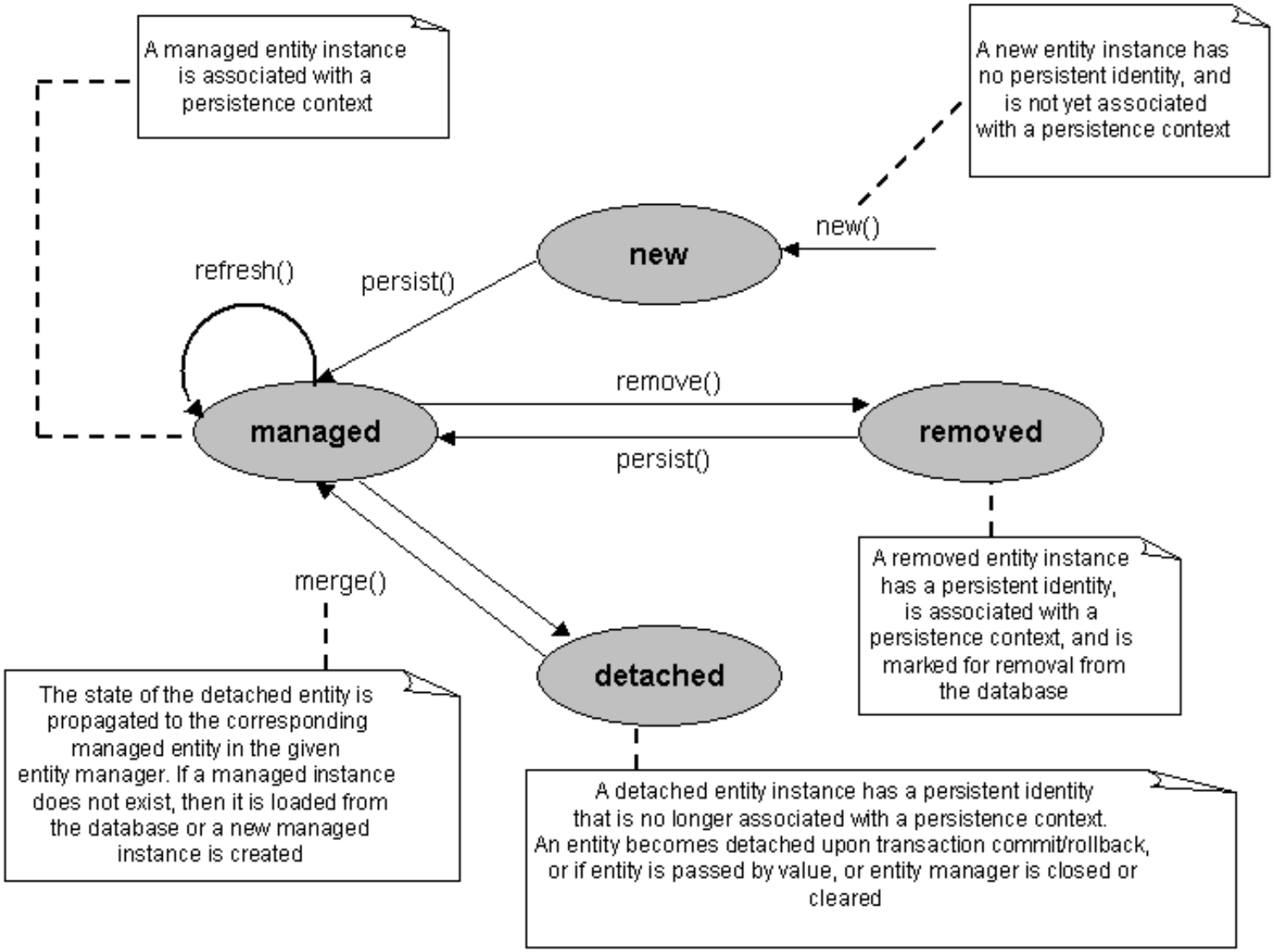


# Entity Lifecycle

- New – entity is instantiated but not associated with persistence context. Not linked to database.
- Managed – associated with persistence context. Changes get syncronised with database
- Detached – has an id, but not connected to database
- Removed – associated with persistence context, but underlying row will be deleted.

- The state of persistent entities is synchronized to the database when the transaction commits

# Entitiy Lifecycle



# Entity Manager

- The EntityManager API:
  - creates and removes persistent entity instances
  - finds entities by the entity's primary key
  - allows queries to be run on entities
- There are two types of EntityManagers:
  - Application-Managed EntityManagers
    - ie: run via Java SE
  - Container-Managed EntityManagers
    - ie: run via Java EE Container eg: JBossAS, GlassFish,…

# Container-Managed Entity Managers (JavaEE)

- With a container-managed entity manager, an EntityManagerinstance 's persistence context is automatically propagated by the container to all application components that use the EntityManagerinstance within a single Java Transaction API (JTA) transaction.
- The Java EE container manages the lifecycle of container-managed entity managers.
- To obtain an EntityManager instance, inject the entity manager into the application component:

```
@PersistenceContext
private EntityManager em;
```

# Application-Managed EntityManager (JavaSE)

- Java SE applications create EntityManager instances by using directly Persistence and EntityManagerFactory:
  - javax.persistence.Persistence
    - Root class for obtaining 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

```
EntityManagerFactory fac =
        Persistence.createEntityManagerFactory("JPADemo");
EntityManager em = fac.createEntityManager();
```

# Entity Transactions (In JavaSE)

- Only used by resource-local EntityManagers
- Transaction demarcation under explicit application control using EntityTransaction API

  begin(), commit(), rollback(), isActive()
- Underlying (JDBC) resources allocated by EntityManager as required

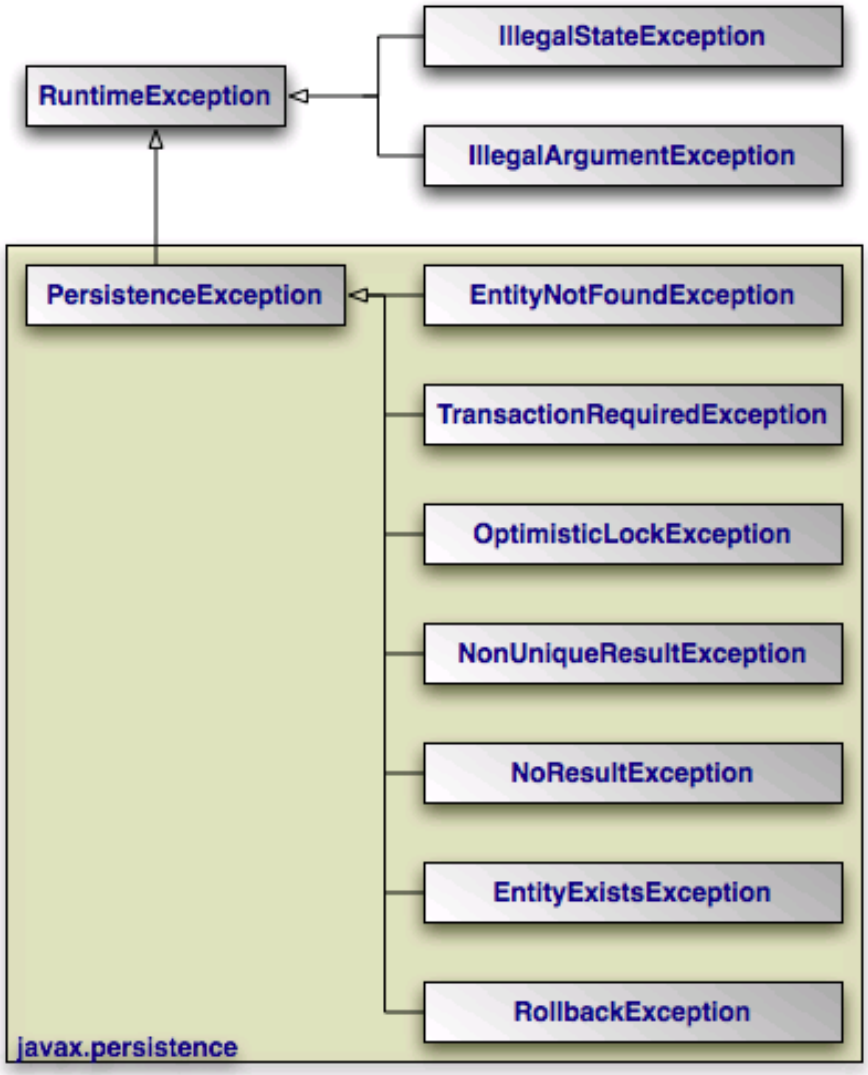
```
EntityTransaction trs = entityManager.getTransaction();
try {
    trs.begin();
    //do your works...
    trs.commit();
} catch (Exception e) {
    trs.rollback();
}
```

# Operations on Entity Objects

- EntityManager API operations:
  - persist() - Save the entity into the db
  - remove() - Delete the entity from the db
  - refresh() - Reload the entity state from the db
  - merge() - Synchronize a detached entity with the p/c
  - find() - Find by primary key
  - createQuery() - Create query using dynamic JP QL
  - createNamedQuery() - Create a predefined query
  - createNativeQuery() - Create a native "pure" SQL query. Can also call stored procedures.
  - contains() - Is entity is managed by p/c
  - flush() - Force synchronization of p/c to database
- Note: p/c == the current persistence context

# JPA exceptions

# JPA exceptions




- All exceptions are unchecked
- Exceptions in javax.persistence package are self-explanatory

# JPA Query Language (JPAQL)

JPA Query Language

- JPA has a query language based on SQL
- JPQL is an extension of EJB QL
- More robust flexible and object-oriented than SQL
- The persistence engine parses the query string, transform the JPQL to the native SQL before executing it

# Creating Queries

- Query instances are obtained using:
  - EntityManager.createNamedQuery (static query)
  - EntityManager.createQuery (dynamic query)
  - EntityManager.createNativeQuery (native query)
- 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

# Static (Named) Queries

- Defined statically with the help of @NamedQuery annotation together with the entity class
- @NamedQuery elements:
  - name - the name of the query that will be used with the createNamedQuery method
  - query - query string

```
@NamedQuery(name="Customer.findAll",
            query="SELECT c FROM Customer c")
```

```
Query findAllQuery = entityManager.createNamedQuery(
                        "findAllCustomers");
List customers = findAllQuery.getResultList();
```

# Multiple Named Queries

- Multiple named queries can be logically defined with the help of @NamedQueries annotation

```
@NamedQueries(
    {
        @NamedQuery(name = "Mobile.selectAllQuery"
            query = "SELECT M FROM MOBILEENTITY M"),
        @NamedQuery(name = "Mobile.deleteAllQuery"
            query = "DELETE M FROM MOBILEENTITY M")
    }
)
```

# Dynamic Queries

- Dynamic queries are queries that are defined directly within an application's business logic
- Not efficient & slower. Persistence engine has to parse, validate & map the JPQL to SQL at run-time

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

# Named Parameters

- Named parameters are parameters in a query that are prefixed with a colon (:)
- To bound parameter to an argument use method:
  - Query.setParameter(String name, Object value)

```
public List findWithName(String name) {
 return em.createQuery(
"SELECT c FROM Customer c WHERE c.name LIKE :custName")
        .setParameter("custName", name)
        .getResultList();
}
```

# Positional Parameters

- Positional parameters are prefixed with a question mark (?) & number of the parameter in the query
  - To set parameter values use method:

    Query.setParameter(integer position, Object value)

```
public List findWithName(String name) {
        return em.createQuery(
"SELECT c FROM Customer c WHERE c.name LIKE ?1")
        .setParameter(1, name)
        .getResultList();
}
```

# Native Queries

- Queries may be expressed in native SQL
- Use when you need to use native SQL of the target database
- Can call stored procedures using "call procname" syntax

```
Query q = em.createNativeQuery(
  "SELECT o.id, o.quantity, o.item " +
  "FROM Order o, Item i " +
  "WHERE (o.item = i.id) AND (i.name = 'widget')",
  com.acme.Order.class);
```

Use @SqlResultSetMapping annotation for more advanced cases

# Query Operations – Multiple Results

- Query.getResultList() will execute a query and may return a List object containing multiple entity instances

```
Query query = entityManager.createQuery("SELECT C FROM CUSTOMER");
List<MobileEntity> mobiles = (List<MobileEntity>)query.getResultList();
```

- Will return a non-parameterized List object
- Can only execute on select statements as opposed to UPDATE or DELETE statements
- For a statement other than SELECT run-time IllegalStateException will be thrown

# Query Operations – Single Result

- A query that returns a single entity object

```
Query singleSelectQuery = entityManager.createQuery(
"SELECT C FROM CUSTOMER WHERE C.ID = 'ABC-123'");
Customer custObj = singleSelectQuery.getSingleResult();
```

- If the match wasn't successful, then EntityNotFoundException is returned
- If more than one matches occur during query execution a run-time exception NonUniqueResultException will be thrown

# Paging Query Results

```
int maxRecords = 10; int startPosition = 0;
String queryString = "SELECT M FROM MOBILEENTITY";
while(true){
   Query selectQuery = entityManager.createQuery(queryString);
   selectQuery.setMaxResults(maxRecords);
   selectQuery.setFirstResult(startPosition);
   List<MobileEntity> mobiles =
        entityManager.getResultList(queryString);
   if (mobiles.isEmpty()){ break; }
   process(mobiles);           // process the mobile entities
   entityManager.clear();      // detach the mobile objects
   startPosition = startPosition + mobiles.size();
}
```

# Flushing Query Objects

- Two modes of flushing query objects
  - **AUTO** (default) and **COMMIT**

- AUTO - any changes made to entity objects will be reflected the very next time when a SELECT query is made

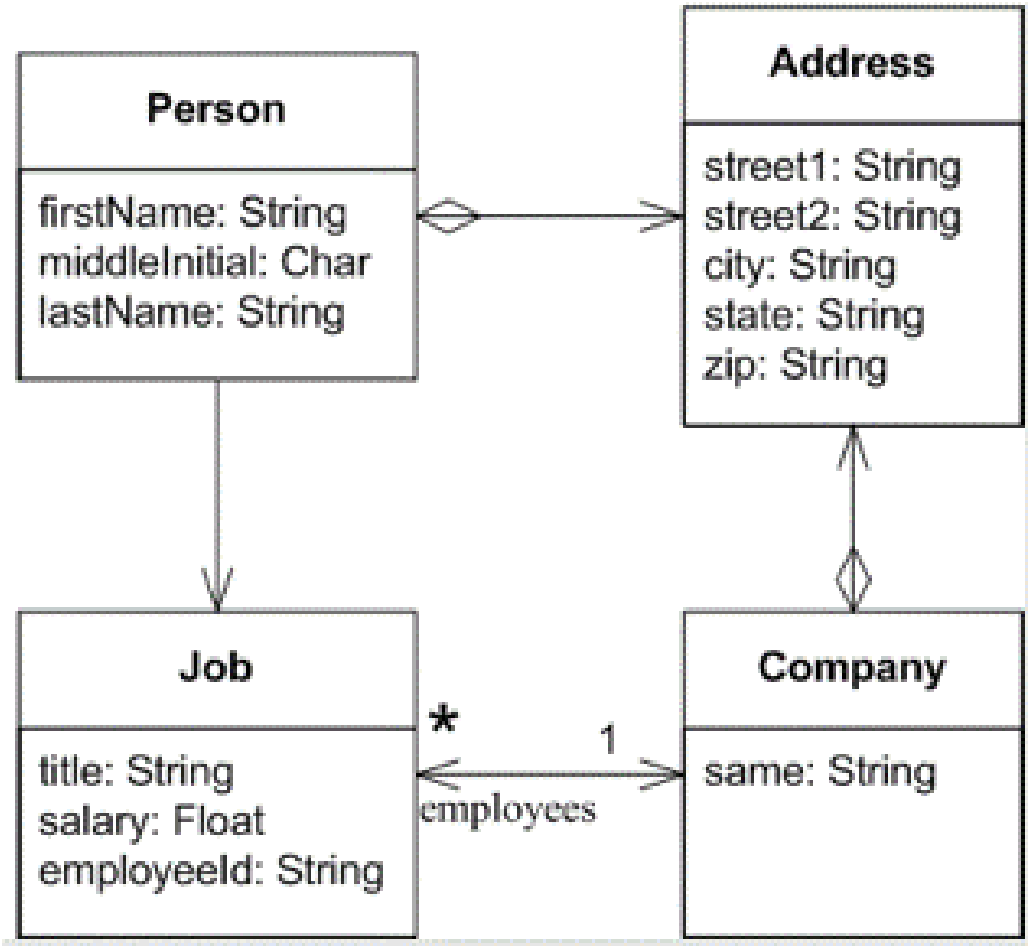
- COMMIT - the persistence engine may only update all the state of the entities during the database COMMIT

- set via Query.setFlushMode()

# Exercises

1. Define an entity class Student which has Id, FirstName and LastName.
2. Define an entity class Course which has Id, name and list of students.
3. Create a database matching the entity classes. Use Apache Derby and its built-in identity columns support.
4. Create a program that lists all classes and the students in each class.
5. Create a program that adds a new class and few students inside it.

# Exercises



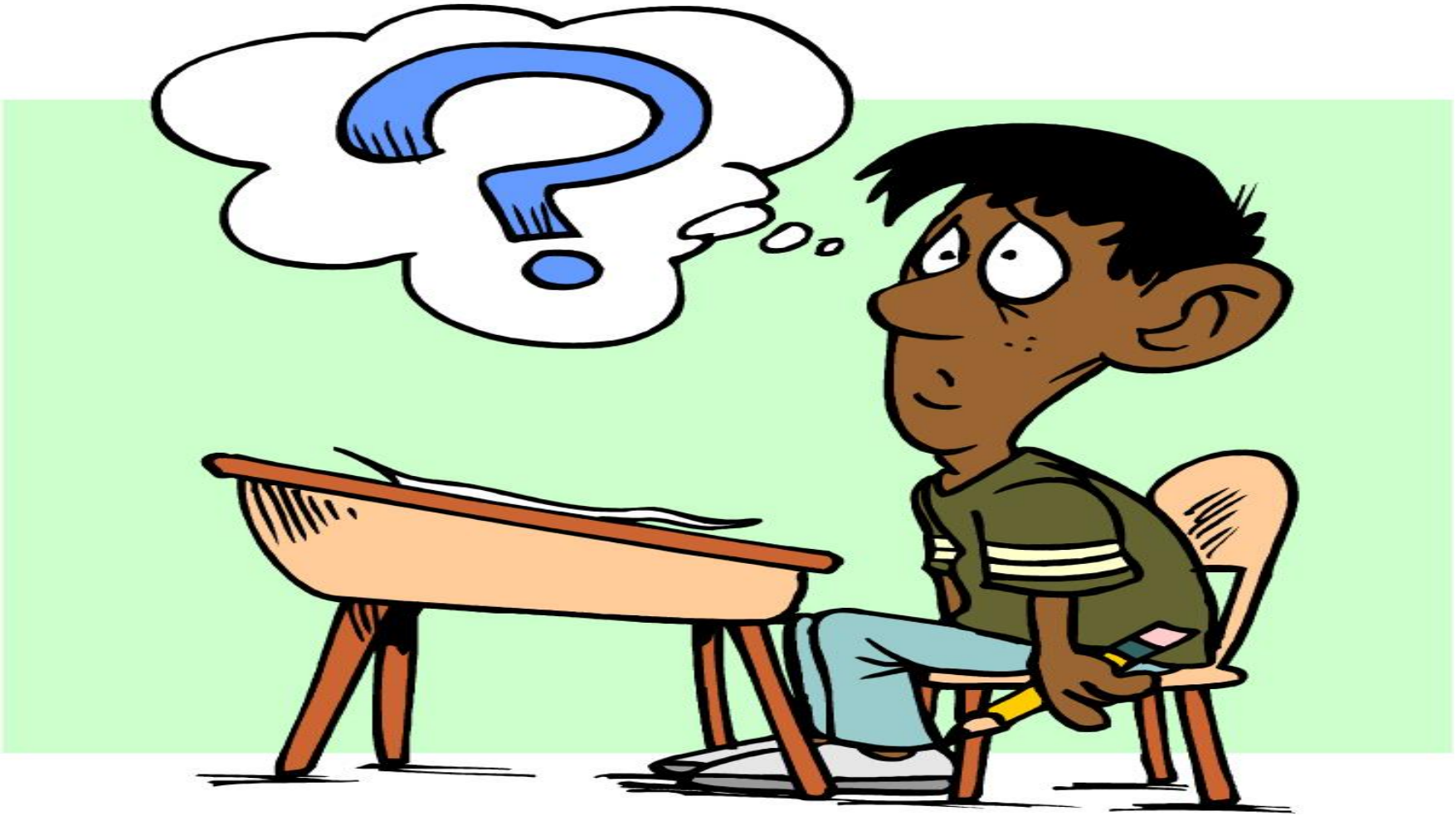

Define an entity class and mapping (relationship) among these objects

## Summary

# The Java Persistence API

- Entities
- EntityManager & the Persistent Context
- Persistence Units
- Exceptions
- JPA Query Language

# FAQ



# *That's all for this session!*

**Thank you all for your attention and patient !**