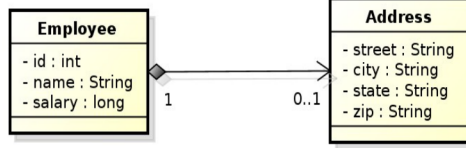


| EMPLOYEE |          |
|----------|----------|
| PK       | ID       |
|          | NAME     |
|          | SALARY   |
|          | STREET   |
|          | CITY     |
|          | STATE    |
|          | ZIP_CODE |



#### @Embeddable

```

@Access(AccessType.FIELD)
public class Address {
    private String street;
    private String city;
    private String state;
    @Column(name="ZIP_CODE")
    private String zip;
}
  
```

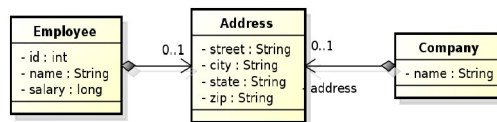
#### @Entity

```

public class Employee {
    @Id private int id;
    private String name;
    private long salary;
    @Embedded
    private Address address;
}
  
```

| EMPLOYEE |             |
|----------|-------------|
| PK       | ID          |
|          | NAME        |
|          | SALARY      |
|          | STREET      |
|          | CITY        |
|          | PROVINCE    |
|          | POSTAL_CODE |

| COMPANY |          |
|---------|----------|
| PK      | NAME     |
|         | STREET   |
|         | CITY     |
|         | STATE    |
|         | ZIP_CODE |



#### @Entity

```

public class Employee {
    @Id private int id;
    private String name;
    private long salary;
    @Embedded
    @AttributeOverrides({
        @AttributeOverride(name="state", column=@Column(name="PROVINCE")),
        @AttributeOverride(name="zip", column=@Column(name="POSTAL_CODE"))
    })
    private Address address;
}
  
```

## 1 Advanced JPA

### 1.1 Embedded Objects

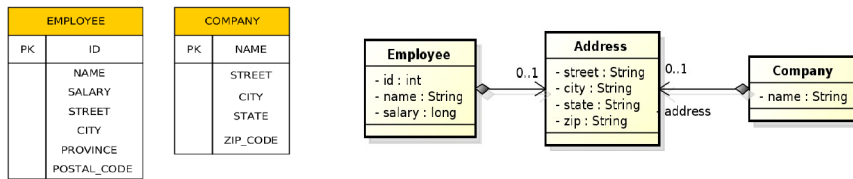
#### Embedded Objects

#### Embedded Objects with Attribute Overriding

#### Embedded Objects with Attribute Overriding II

### 1.2 Mapping Legacy Databases

#### Mapping Legacy Databases



```

@Entity
public class Company {
    @Id private String name;
    @Embedded
    private Address address;
}

```

## 2. Multiple entities to one table: *@Embedded*, *@EmbeddedId*, *@Embeddable*

```

@Entity
public class Person {
    @Id
    private Long id;
    private String hasName;

    @Embedded
    private Birth birth;
    // getters + setters
}

```

```

@Embeddable
public class Birth {
    private String hasPlace;

    @Temporal(value=TemporalType.DATE)
    private Date hasDateOfBirth;
    // getters + setters
}

```

```

PERSON
=====
ID bigint PRIMARY KEY NOT NULL
HASNAME varchar(255)
HASDATEOFBIRTH date
HASPLACE varchar(255)

```

## 1. One entity to many tables: `@SecondaryTable`, `@Column(table=...)`

```
@SecondaryTables({
    @SecondaryTable(name="ADDRESS")
})
public class Person {

    @Id
    private Long id;

    @Column(table="ADDRESS")
    private String city;

    // getters + setters
}
```

```
PERSON
=====
ID bigint PRIMARY KEY NOT NULL
HASNAME varchar(255)
```

```
ADDRESS
=====
ID bigint
    PRIMARY KEY NOT NULL
CITY varchar(255)
FOREIGN KEY (id)
    REFERENCES person (id)
```

## Mapping Legacy Databases

### 1.3 Cascades

#### Cascading Operations

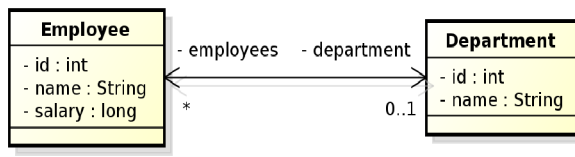
- Cascading allows to apply selected entity manager operations transitively to referenced entities
- Cascading types:
  - `CascadeType.ALL`
  - `CascadeType.PERSIST`
  - `CascadeType.MERGE`
  - `CascadeType.REMOVE`
  - `CascadeType.REFRESH`
  - `CascadeType.DETACH`

#### Cascade Persist

```
@Entity
public class Employee {
    // ...
    @ManyToOne(cascade=CascadeType.PERSIST)
    private Address address;
    // ...
}
```

#### Cascade Best Practices

Cascading only makes sense for *dependent* entities (weak entities)– those that cannot exist without the independent entity.



```

@Entity
public class Employee {
    // ...
    @ManyToOne(cascade=CascadeType.PERSIST)
    private Address address;
    // ...
}
  
```

```

Employee emp = new Employee();
emp.setName("Sherlock");
emp.setSalary(25000);
Address addr = new Address();
addr.setStreet("Baker Street");
addr.setCity("London");
addr.setCountry("British Empire");
emp.setAddress(addr);

// em.persist(addr); -- Not needed anymore
em.persist(emp);
  
```

## Cascading and Bidirectional Relationships

```

final Department dept = new Department();
dept.setName("Accounting");
final Employee emp = new Employee();
emp.setName("Rob");
emp.setSalary(25000);
// @OneToMany(mappedBy="department", cascade = CascadeType.PERSIST)
dept.getEmployees().add(emp);

em.persist(dept);
  
```

```
emp.getDepartment() == null
```

## Making bidirectional relationship cascadable

Cascading only makes sense for *dependent* entities (weak entities)– those that cannot exist without the independent entity. We must ensure proper initialization of the relationship *owner*.

```

@Entity
public class Address {
    // ...
    @OneToMany(cascade=CascadeType.PERSIST, mappedBy="address")
    private List<Employee> employees = new ArrayList<>();
    // ...

    private void addEmployee(final Employee employee) {
        employees.add(employee);
    }
}
  
```

```

@Entity
public class Employee {
    @Id private int id;
    private String name;
    private long salary;
    // ...
    @ElementCollection(targetClass=VacationEntry.class);
    private Collection vacationBookings;

    @ElementCollection
    private Set<String> nickName;
    // ...
}

@Embeddable
public class VacationEntry {
    @Temporal(TemporalType.DATE)
    private Calendar startDate;

    @Column(name="DAYS")
    private int daysTaken;
    // ...
}

```



```

    employee.setAddress(this);
}

private void removeEmployee(final Employee employee) {
    employees.remove(employee);
    employee.setAddress(null);
}
}

```

## 2 Collection Mapping

### Collection Mapping

- Collection-valued relationships
  - @OneToMany
  - @ManyToMany
- **Element collections** – since JPA 2.0
  - @ElementCollection
  - Collections of embeddables
  - Collections of basic types
  - Lists, Maps

### Collection Mapping

### Collection Mapping

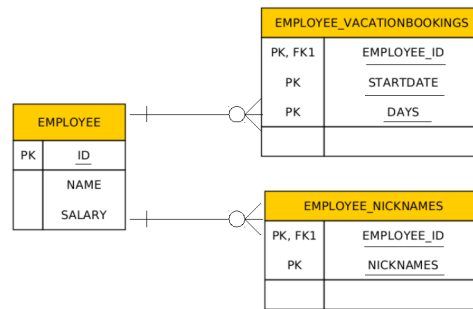
### Collection Mapping

```

@Entity
public class Employee {
    @Id private int id;
    private String name;
    private long salary;
    // ...
    @ElementCollection(targetClass=VacationEntry.class);
    private Collection vacationBookings;

    @ElementCollection
    private Set<String> nickName;
    // ...
}

```

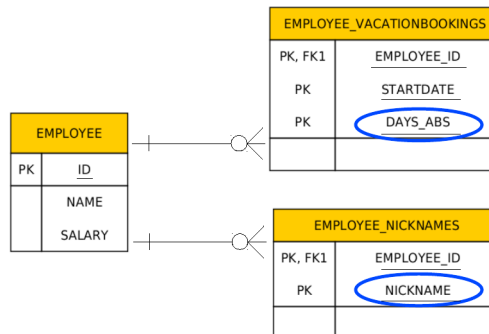


```

@Entity
public class Employee {
    @Id private int id;
    private String name;
    private long salary;
    // ...
    @ElementCollection(targetClass = VacationEntry.class);
    @CollectionTable(
        name="VACATION",
        joinColumn=@JoinColumn(name="EMP_ID", column="DAYS_ABS")
    )
    @AttributeOverride(name="daysTaken", column="DAYS_ABS")
    private Collection vacationBookings;

    @ElementCollection
    @Column(name="NICKNAME")
    private Set<String> nickName;
    // ...
}

```

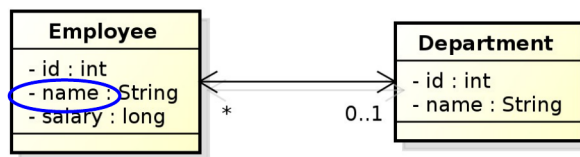


```

@Embeddable
public class VacationEntry {
    @Temporal(TemporalType.DATE)
    private Calendar startDate;

    @Column(name="DAYS")
    private int daysTaken;
    // ...
}

```



```

@Entity
public class Department {
    // ...
    @OneToMany(mappedBy="department")
    @OrderBy("name ASC")
    private List<Employee> employees;
    // ...
}
  
```

Figure 1: Ordering by Entity or Element Attribute

## 2.1 Ordering

### Collection Mapping – List Ordering

- Ordering by entity or element attribute
  - Ordering according to the state that exists in each entity or element in the list
  - `@OrderBy`
  - Multiple attributes can be specified
- Persistently ordered lists
  - Ordering by means of database column(s)
  - Typically, instances are in the order in which they were inserted into the table

### Collection Mapping – List Ordering

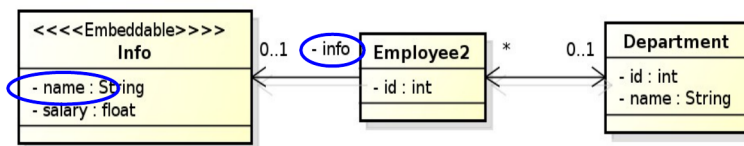
### Collection Mapping – List Ordering

### Collection Mapping – List Ordering

## 2.2 Maps

### Collection Mapping – Maps

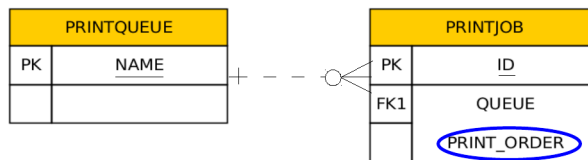
- Map is a collection that maps keys to values
- It cannot contain duplicate keys, each key can map to at most one value
- Keys



```

@Entity
public class Department {
    // ...
    @OneToMany(mappedBy="department")
    @OrderBy("info.name ASC")
    private List<Employee2> employees;
    // ...
}
  
```

Figure 2: Ordering by Entity or Element Attribute



```

@Entity
public class PrintQueue {
    @Id private String name;
    // ...
    @OneToMany(mappedBy="queue")
    @OrderColumn(name="PRINT_ORDER")
    private List<PrintJob> jobs;
    // ...
}
  
```

This annotation need not be necessarily on the owning side

Figure 3: Persistently ordered lists

```

@Entity
public class Employee {
    @Id private int id;
    private String name;
    private long salary;

    @ElementCollection
    @CollectionTable(name="EMP_PHONE")
    @MapKeyColumn(name="PHONE_TYPE")
    @Column(name="PHONE_NUM")
    private Map<String, String> phoneNumbers;
    // ...
}

```

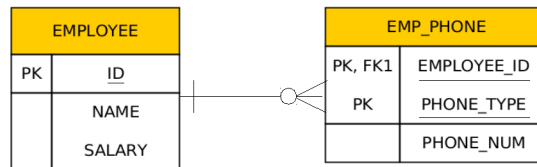


Figure 4: Basic type key – String

- Basic types (incl. enums) – stored directly in the table being referred to
    - \* Join table
    - \* Collection table
    - \* Target entity table
  - Embeddable types
    - \* DTO
  - Entities – only foreign key is stored in the table
- Values
    - Entities – @OneToMany or @ManyToMany
    - Basic or embeddable types – mapped to an element collection

## Collection Mapping

## Collection Mapping

## Collection Mapping

## Collection Mapping

## Collection Mapping

## Collection Mapping

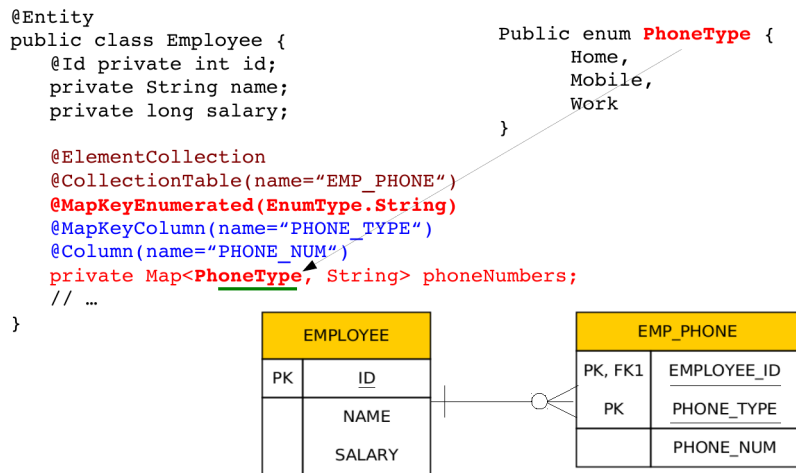


Figure 5: Basic type key – enumeration

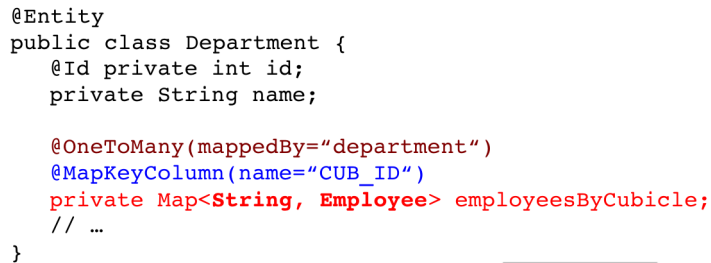


Figure 6: Basic type key – 1:N relationship using a Map with a String key

```

@Entity
public class Department {
    @Id private int id;
    private String name;

    @ManyToMany
    @JoinTable(name="DEPT_EMP",
        joinColumns=@JoinColumn(name="DEPT_ID"),
        inverseJoinColumns=@JoinColumn(name="EMP_ID"))
    @MapKeyColumn(name="CUB_ID")
    private Map<String, Employee> employeesByCubicle;
    // ...
}

```

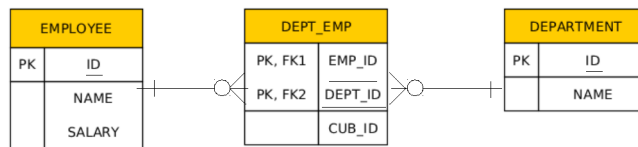


Figure 7: Basic type key – N:M relationship using a Map with a String key

```

@Entity
public class Department {
    // ...
    @OneToMany(mappedBy="department")
    @MapKey(name="id")
    private Map<Integer, Employee> employees;
    // ...
}

```

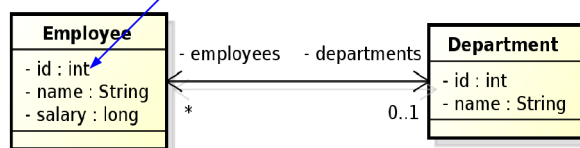


Figure 8: Entity attribute key

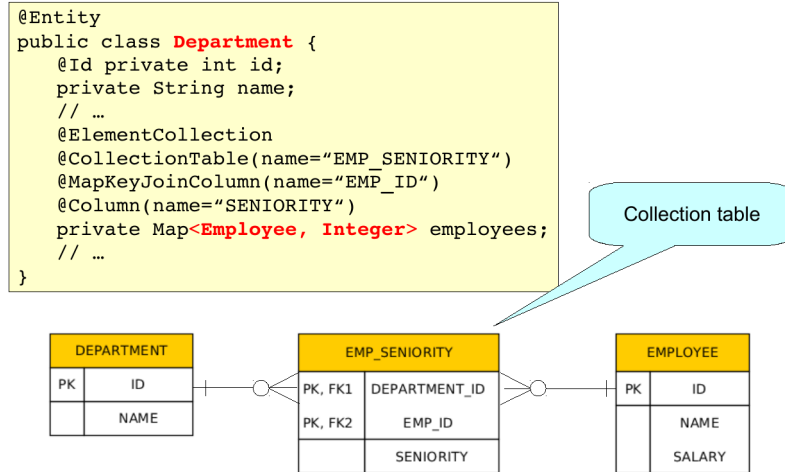


Figure 9: Entity as a key

| EMPLOYEE |         |
|----------|---------|
| PK       | COUNTRY |
| PK       | EMP_ID  |
|          | NAME    |
|          | SALARY  |

## 3 Compound and Shared Keys

### 3.1 Compound Primary Keys

**Compound Primary Keys – @IdClass**

```

public class EmployeeId implements Serializable {
    private String country;
    private Integer id;
}

```

```

@Entity
@IdClass(EmployeeId.class)
public class Employee {
    @Id
    private String country;
    @Id
    @Column(name="EMP_ID")
    private Integer id;

    private String name;
    private Long salary;
    // ...
}

```

Usage:

```

em.createQuery("SELECT e FROM Employee e WHERE e.country = :country AND e.id = :id",
    Employee.class).getSingleResult();
// OR

```

| EMPLOYEE |         |
|----------|---------|
| PK       | COUNTRY |
| PK       | EMP_ID  |
|          | NAME    |
|          | SALARY  |

```
EmployeeId id = new EmployeeId(country, id);
em.find(Employee.class, id);
```

**Compound Primary Keys – @EmbeddedId**

```
@Embeddable
public class EmployeeId implements Serializable {
    private String country;
    @Column(name="EMP_ID")
    private Integer id;
}
```

```
@Entity
public class Employee {
    @EmbeddedId
    private EmployeeId id;

    private String name;
    private Long salary;
    // ...
}
```

Usage:

```
em.createQuery("SELECT e FROM Employee e WHERE e.id.country = :country AND e.id.id = :id", Employee.class).getSingleResult();
// OR
EmployeeId id = new EmployeeId(country, id);
em.find(Employee.class, id);
```

## 3.2 Shared Primary Keys

### Shared Primary Key

```
@Entity
public class Employee {
    @Id
    private Integer id;
    private String name;

    @OneToOne(mappedBy = "employee", cascade = CascadeType.ALL)
    private EmployeeDetail detail;
    // ...
}
```

```
@Entity
public class EmployeeDetail {

    @Id
    private Integer id;
```

```

@MapsId
@OneToOne
private Employee employee;
// ...
}

```

- The primary key of EmployeeDetail is of the same type as Employee
  - Can be compound as well
- Relationship owner must be the entity with dependent id
- The relationship need not be bidirectional

### Shared Primary Key

```

@Entity
public class Employee {
    @Id
    private Integer id;
    private String name;

    @OneToOne(mappedBy = "employee", cascade = CascadeType.ALL)
    private EmployeeDetail detail;
    // ...
}

```

```

@Entity
public class EmployeeDetail {

    @Id
    @OneToOne
    private Employee employee;
    // ...
}

```

- The primary key in the dependent entity need not be explicitly mapped to an attribute

## 3.3 Compound Join Columns

### Compound Join Columns

### Compound Join Columns

## 4 Various Attributes and Access Types

### Read-only Mapping and Optionality

| EMPLOYEE |                |
|----------|----------------|
| PK       | <u>COUNTRY</u> |
| PK       | <u>EMP_ID</u>  |
|          | NAME           |
|          | SALARY         |
| FK1      | MGR_COUNTRY    |
| FK1      | MGR_ID         |

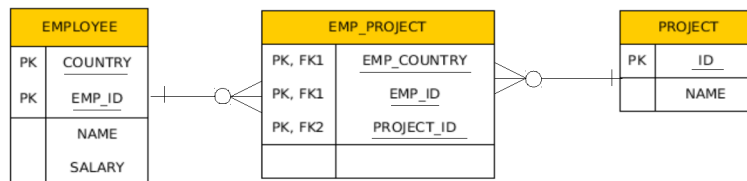
```

@Entity
@IdClass(EmployeeId.class)
public class Employee {
    @Id private String country;
    @Id
    @Column(name="EMP_ID")
    private int id;

    @ManyToOne
    @JoinColumns({
        @JoinColumn(name="MGR_COUNTRY",
            referencedColumnName="COUNTRY"),
        @JoinColumn(name="MGR_ID",
            referencedColumnName="EMP_ID")
    })
    private Employee manager;

    @OneToMany(mappedBy="manager")
    private Collection<Employee> directs;
    // ...
}

```



```

@Entity
@IdClass(EmployeeId.class)
public class Employee {
    @Id private String country;
    @Id
    @Column(name="EMP_ID")
    private int id;
    @ManyToMany
    @JoinTable(
        name="EMP_PROJECT",
        joinColumns={
            @JoinColumn(name="EMP_COUNTRY", referencedColumnName="COUNTRY"),
            @JoinColumn(name="EMP_ID", referencedColumnName="EMP_ID")},
        inverseJoinColumns=@JoinColumn(name="PROJECT_ID"))
    private Collection<Project> projects;
}

```

```

@Entity
public class EmployeeView {
    @Id
    private Integer id

    @Column(insertable=false, updatable=false)
    private String name;

    @ManyToOne(optional = false)
    @JoinColumn(name="DEPT_ID", insertable=false, updatable=false)
    private Department department;
    // ...
}

```

- @Column attributes are written also into DDL
- Checked on commit

## Overriding Mapping

- @AttributeOverride allows to override mapping of basic and ID attributes
- May be applied also to element collections
- Allows to override mapping inherited from a mapped superclass or from an embeddable class

## Overriding Mapping – Example

```

@Embeddable
public class Address {

    protected String street;
    protected String city;
    protected String state;

    @Embedded
    protected Zipcode zipcode;
}

@Embeddable
public class Zipcode {

    protected String zip;
    protected String plusFour;
}

```

```

@Entity
public class Customer {

    @Id
    protected Integer id;
    protected String name;

    @AttributeOverrides({

```

```

        @AttributeOverride(name="state",
            column=@Column(name="ADDR_STATE")),
        @AttributeOverride(name="zipcode.zip",
            column=@Column(name="ADDR_ZIP"))
    })
    @Embedded
    protected Address address;
    // ...
}

```

## Access types – Field access

```

@Entity
public class EmployeeView {
    @Id
    private Integer id;
    private String name;
    // ...
    public Integer getId() {return id;}
    public void setId(Integer id) {this.id = id;}
    public String getName() {return name;}
    public void setName(String name) {this.name = name;}
}

```

- Provider will get and set attribute values directly via fields
- *Getters/setters will not be invoked*

## Access types – Property access

```

@Entity
public class EmployeeView {
    private Integer id;
    private String name;
    // ...
    @Id
    public Integer getId() {return id;}
    public void setId(Integer id) {this.id = id;}
    public String getName() {return name;}
    public void setName(String name) {this.name = name;}
}

```

- Annotate getter or setter
- Provider will get and set attribute values by invoking getters and setters

## Access types – Mixed access

- Field access with property access can be combined within the same entity or within the same entity hierarchy
- @Access defines default access mode for entity
  - May be overridden for subclasses

JPQL very similar to SQL (especially in JPA 2.0)

```
SELECT p.number
FROM Employee e JOIN e.phones p
WHERE e.department.name = 'NA42' AND p.type = 'CELL'
```

Conditions do not stick on values of database columns, but on entities and their properties.

```
SELECT d, COUNT(e), MAX(e.salary), AVG(e.salary)
FROM Department d JOIN d.employees e
GROUP BY d
HAVING COUNT(e) >= 5
```

- positional

```
SELECT e
FROM Employee e
WHERE e.department = ?1 AND e.salary > ?2
```

- named

```
SELECT e
FROM Employee e
WHERE e.department = :dept AND salary > :base
```

## 5 Queries

### Queries

- **JPQL** – Java Persistence Query Language
- **SQL** – native queries
- **Criteria API** – programmatic query API

### 5.1 JPQL

#### JPQL

#### JPQL – Query Parameters

#### JPQL – Using Parameters

```
String QUERY = "SELECT e.salary FROM Employee e " +
               "WHERE e.department.name = :deptName " +
               "AND e.name = :empName";

public long queryEmpSalary(String deptName, String empName) {
    return em.createQuery(QUERY, Long.class)
        .setParameter("deptName", deptName)
        .setParameter("empName", empName)
        .getSingleResult();
}
```

```
@NamedQuery(name="Employee.findByName",
            query="SELECT e FROM Employee e " +
                "WHERE e.name = :name")
```

```
public Employee findEmployeeByName(String name) {
    return em.createNamedQuery("Employee.findByName",
                               Employee.class)
        .setParameter("name", name)
        .getSingleResult();
}
```

## JPQL – Named Queries

## JPQL – Bulk Updates

## 5.2 Native Queries

### Native (SQL) Queries

### Native (SQL) Queries

### Native (SQL) Queries

## 5.3 Criteria API

### Criteria API

```
SELECT p FROM Product p WHERE p.name LIKE '%p%'
```

### Static Metamodel

```
CriteriaBuilder cb = em.getCriteriaBuilder();
CriteriaQuery<Product> cq = cb.createQuery(Product.class);
Root<Product> r = cq.from(Product.class);
cq.where(
```

Modifications of entities not only by `em.persist()` or `em.remove()`;

```
em.createQuery("UPDATE Employee e SET e.manager = ?1 " +
               "WHERE e.department = ?2)
               .setParameter(1, manager)
               .setParameter(2, dept)
               .executeUpdate();
```

```
em.createQuery("DELETE FROM Project p " +
               "WHERE p.employees IS EMPTY")
               .executeUpdate();
```

If REMOVE cascade option is set for a relationship, cascading remove occurs.

Native SQL update and delete operations should not be applied to tables mapped by an entity (transaction, cascading).

```
@NamedNativeQuery(
    name="getStructureReportingTo",
    query = "SELECT emp_id, name, salary, manager_id, "+
            "dept_id, address_id " +
            "FROM emp ",
    resultClass = Employee.class
)
```

Mapping is straightforward

```
@NamedNativeQuery(
    name="getEmployeeAddress",
    query = "SELECT emp_id, name, salary, manager_id, "+
            "dept_id, address_id, id, street, city, " +
            "state, zip " +
            "FROM emp JOIN address "
            "ON emp.address_id = address.id)"
)
```

Mapping less straightforward

```
@SqlResultSetMapping(
    name="EmployeeWithAddress",
    entities={@EntityResult(entityClass=Employee.class),
              @EntityResult(entityClass=Address.class)}
```

```

Query q = em.createNativeQuery(
    "SELECT o.id AS order_id, " +
    "o.quantity AS order_quantity, " +
    "o.item AS order_item, " +
    "i.name AS item_name, " +
    "FROM Order o, Item i " +
    "WHERE (order_quantity > 25) AND (order_item = i.id)",
    "OrderResults");

@SqlResultSetMapping(name="OrderResults",
    entities={
        @EntityResult(entityClass=com.acme.Order.class,
            fields={
                @FieldResult(name="id", column="order_id"),
                @FieldResult(name="quantity",
                    column="order_quantity"),
                @FieldResult(name="item",
                    column="order_item")}},
        columns={
            @ColumnResult(name="item_name")}
    )

```

```

        cb.like(
            r.get(Product_.name)
            , "%p%")
    );
    return em.createQuery(cq).getResultList();

```

## Metamodel

```

Metamodel m = em.getMetamodel();
CriteriaBuilder cb = em.getCriteriaBuilder();
CriteriaQuery<Product> cq = cb.createQuery(Product.class);
Root<Product> r = cq.from(Product.class);
cq.where(
    cb.like(
        r.get(
            m.entity(Product.class)
            .getSingularAttribute("name",
                String.class))
        , "%p%")
    );
return em.createQuery(cq).getResultList();

```

## Query API – Pagination

# 6 Beyond JPA

## Graph Databases

- Comparing to RDBMS – relation types are **first-class citizens**
- Suitable for relaxed data schemas
- Suitable for analytics using graph algorithms

```

private long pageSize    = 800;
private long currentPage = 0;

public List getCurrentResults() {
    return em.createNamedQuery("Employee.findByDept",
                               Employee.class)
        .setFirstResult(currentPage * pageSize)
        .setMaxResults(pageSize)
        .getResultList();
}

public void next() {
    currentPage++;
}

```

- E.g. Neo4j

## Spring Data Neo4j

Model:

```

import org.neo4j.ogm.annotation.*;
@NodeEntity
public class Person {
    @Id @GeneratedValue
    private Long id;
    private String name;

    @Relationship(type = "ACTED_IN")
    private List<Movie> movies = new ArrayList<>();
}

```

Repository:

```

@RepositoryRestResource(collectionResourceRel = "movies", path = "movies")
public interface MovieRepository extends Neo4jRepository<Movie, Long> {
    @Query("MATCH (m:Movie) <- [r:ACTED_IN] - (a:Person) RETURN m,r,a")
    List<Person> getActors();
}

```

## RDF Triple Stores

- Comparing to RDBMS – relation types are **first-class citizens**
- Suitable for relaxed data schemas
- Suitable for Linked Data, Semantic Web, ontologies
- E.g. RDF4J, Virtuoso, Fuseki, Blazegraph, GraphDB, ...

JOPA is a library for accessing triples using Java objects.

## JOPA

Model:

```
import cz.cvut.kbss.jopa.model.annotations.*;

@OWLClass(iri = "http://example.org/ontology/student")
public class Student implements Serializable {

    @Id
    private URI uri;

    @OWLDataProperty(iri = "http://example.org/ontology/email")
    private String email;
}
```

DAO similar to JPA EntityManager. See <https://github.com/kbss-cvut/jopa>

## Resources

- JSR 338 Java Persistence 2.2 Final Release <https://jcp.org/en/jsr/detail?id=338>
- WikiBooks [https://en.wikibooks.org/wiki/Java\\\_Persistence](https://en.wikibooks.org/wiki/Java\_Persistence)

**The End**

Thank You