Advanced JPA

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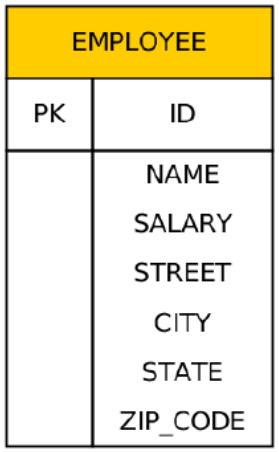
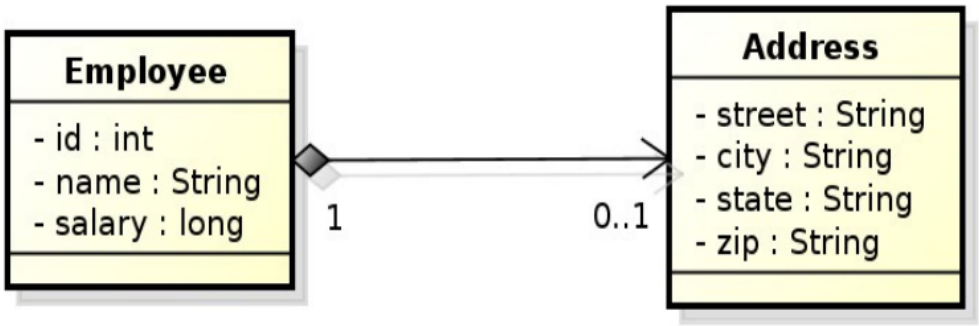
Contents

Advanced JPA

Embedded Objects

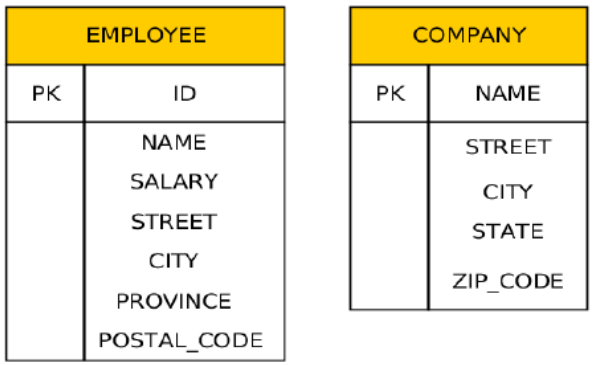


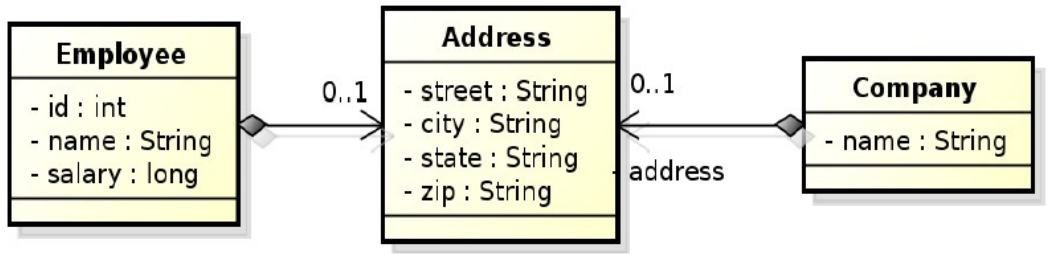



```
@Embeddable
@Access(AccessType.FIELD)
public class Address {
   private String street;
   private String city;
   private String state;
   @Column(name="ZIP_CODE")
   private String zip;
}
```

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

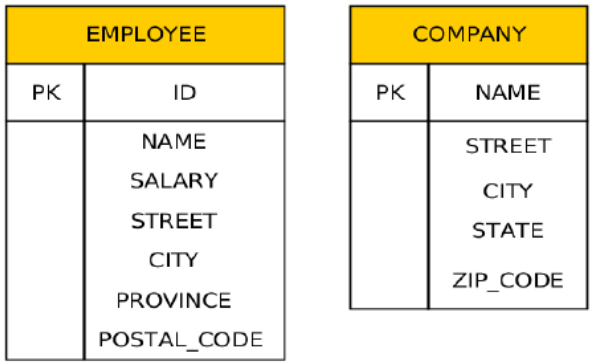
Embedded Objects with Attribute Overriding

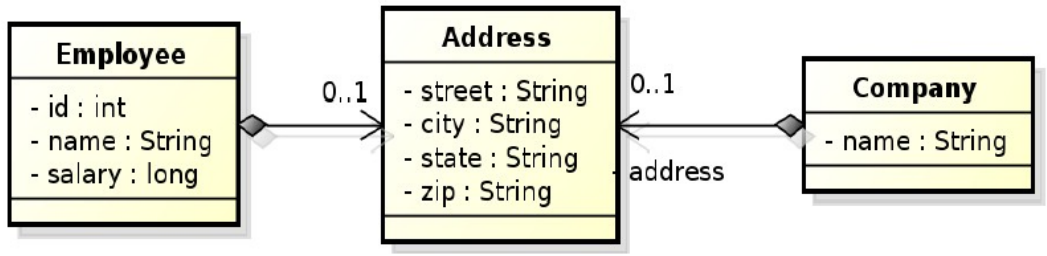





```
@Entity
public class Employee {
    @Id private int id;
    private String name;
    private long salary;
    @Embedded
    @AttributeOverrides({
        @AttributeOverride(name="state", column=@Column(name="PROVINCE")),
        @AttributeOverride(name="zip", column=@Column(name="POSTAL_CODE"))
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

Embedded Objects with Attribute Overriding II






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

Mapping Legacy Databases

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)
```

Mapping Legacy Databases

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)
```

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;
    // ...
}
```

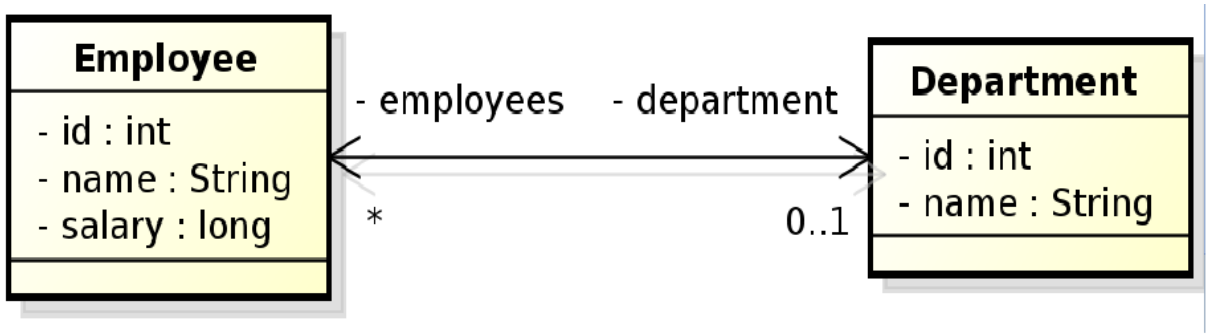
Cascade Best Practices

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



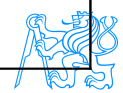

```
final Department dept = new Department();
dept.setName("Accounting");
final Employee emp = new Employee();
emp.setName("Rob");
emp.setSalary(25000);
// @OneToMany(mappedBy="department", cascade = CascadeType.PERSIST)
dept.getEmployees().add(emp);

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);
       employee.setAddress(this);
    }

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



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

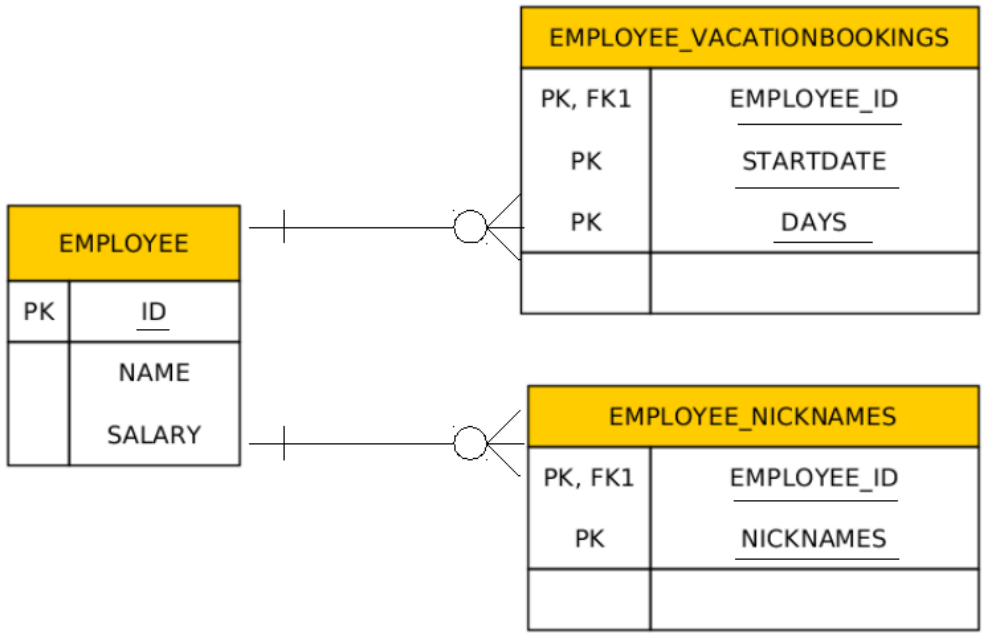
Collection Mapping

```
@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;
   // …
}
```

Collection Mapping

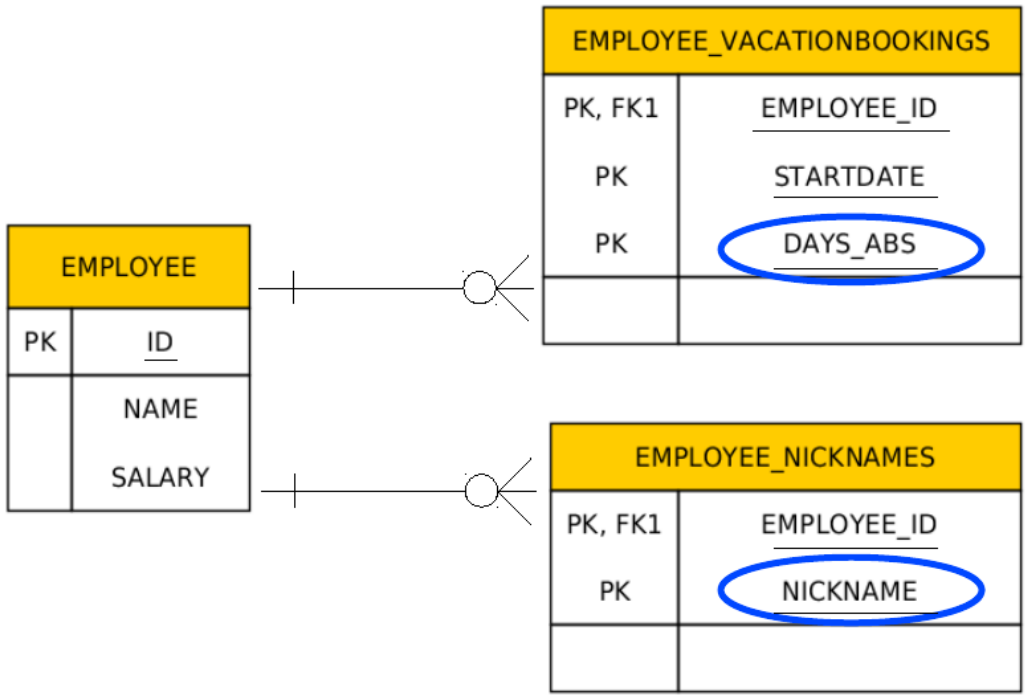
```
@Entity
public class Employee {
   @Id private int id;
   private String name;
   private long salary;
   // …
   @ElementCollection(targetClass=VacationEntry.class);
   private Collection vacationBookings;

   @ElementCollection
   private Set<String> nickName;
   // …
}
```



Collection Mapping

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

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

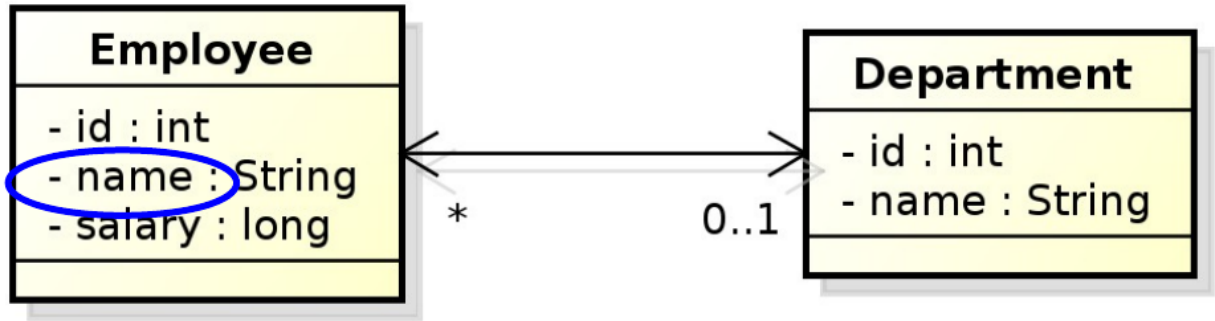
```
@Embeddable
public class VacationEntry {
   @Temporal(TemporalType.DATE)
   private Calendar startDate;

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



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

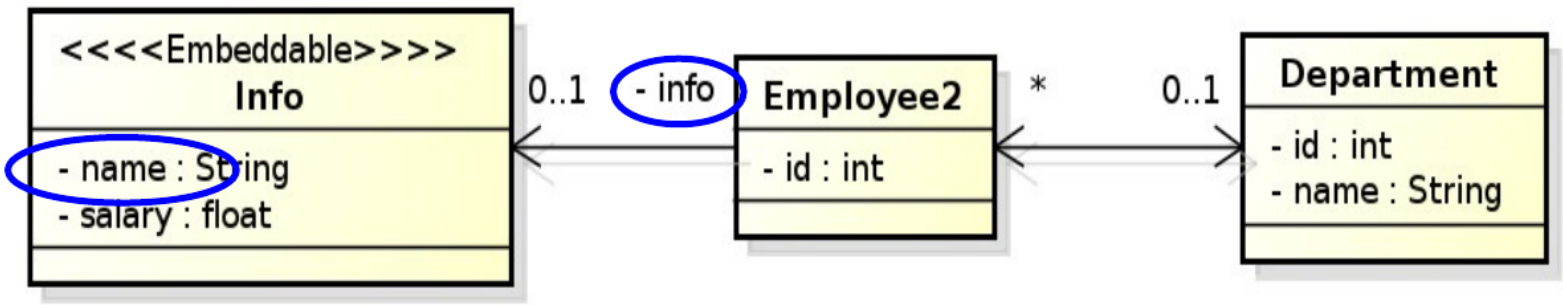
Collection Mapping – List Ordering




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

Figure: Ordering by Entity or Element Attribute

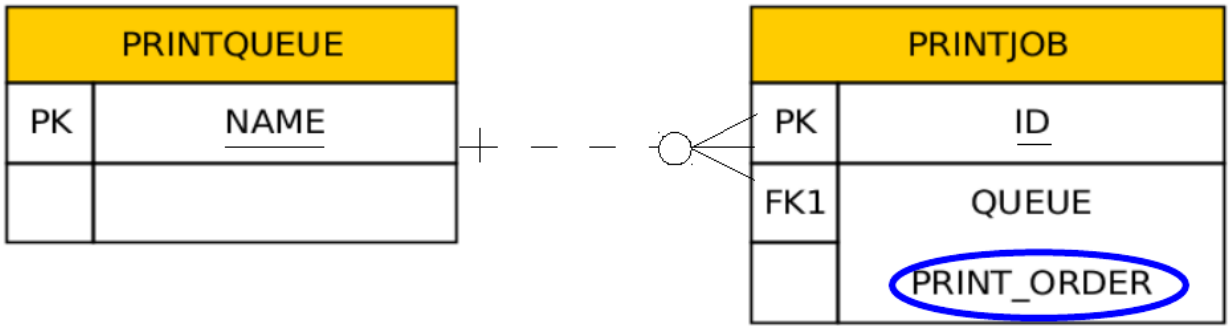
Collection Mapping – List Ordering




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

Figure: Ordering by Entity or Element Attribute

Collection Mapping – List Ordering




```
@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: Persistently ordered lists

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**
  - Basic types (incl. enums) – stored directly in the table being referred to
    - Join table
    - Collection table
    - Target entity table
  - Embeddable types
    - DTTO
  - 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

```
@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;
    // …
}
```

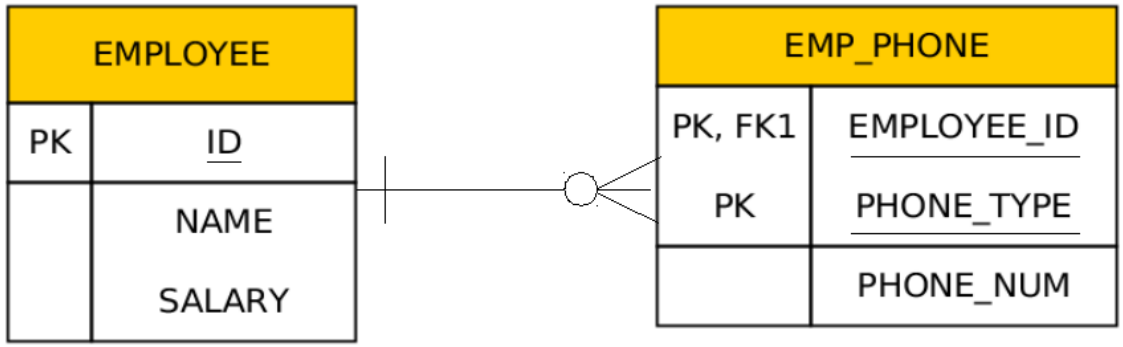


Figure: Basic type key – String

Collection Mapping

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

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

```
Public enum PhoneType {
        Home,
        Mobile,
        Work
}
```

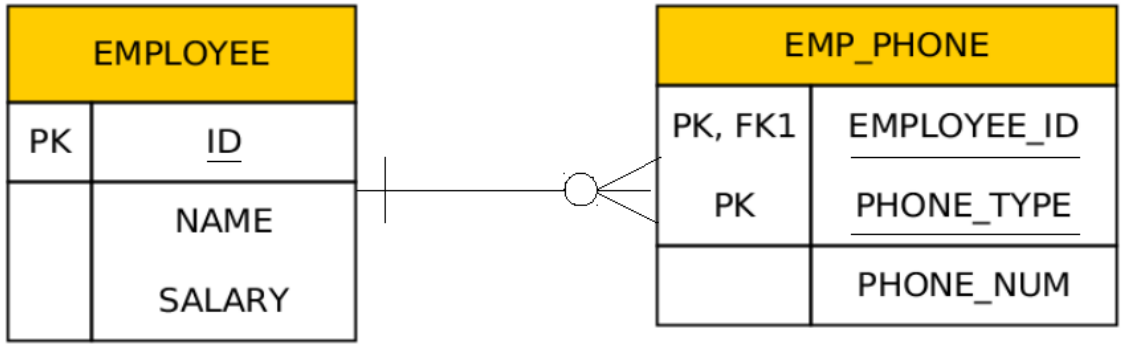


Figure: Basic type key – enumeration

Collection Mapping

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

    @OneToMany(mappedBy="department")
    @MapKeyColumn(name="CUB_ID")
    private Map<String, Employee> employeesByCubicle;
    // …
}
```

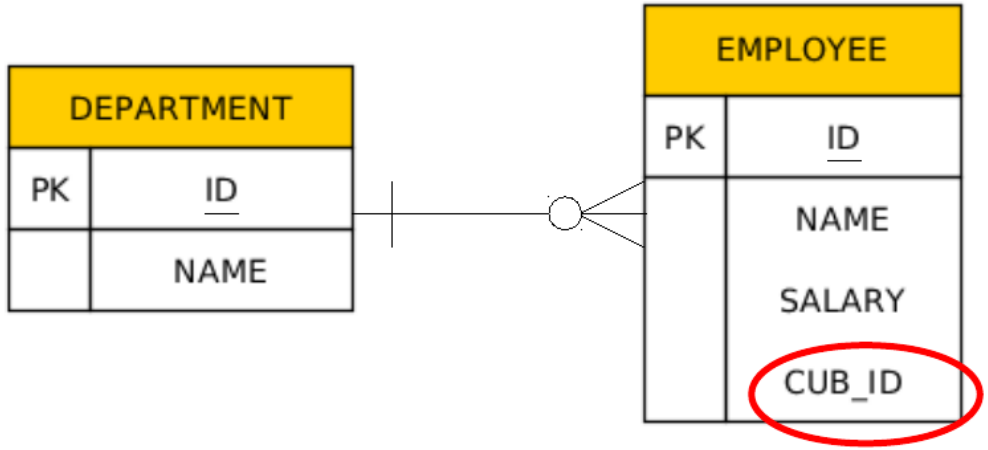


Figure: Basic type key – 1:N relationship using a Map with a String key

Collection Mapping

```
@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;
    // …
}
```

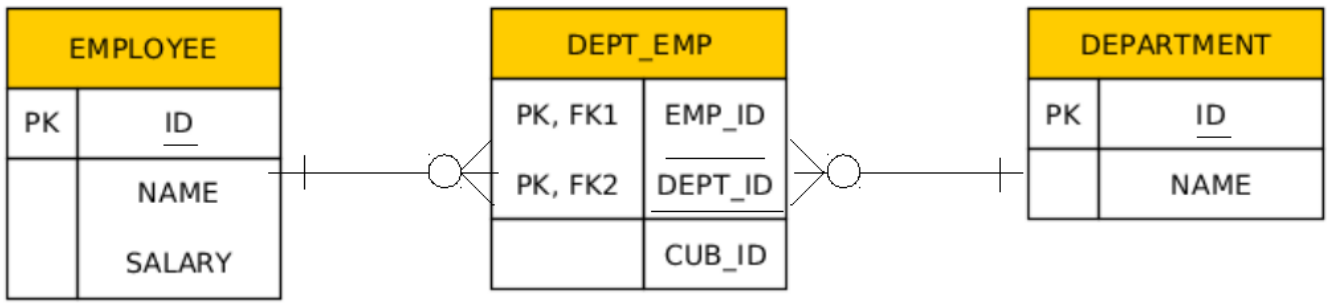


Figure: Basic type key – N:M relationship using a Map with a String key

Collection Mapping

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

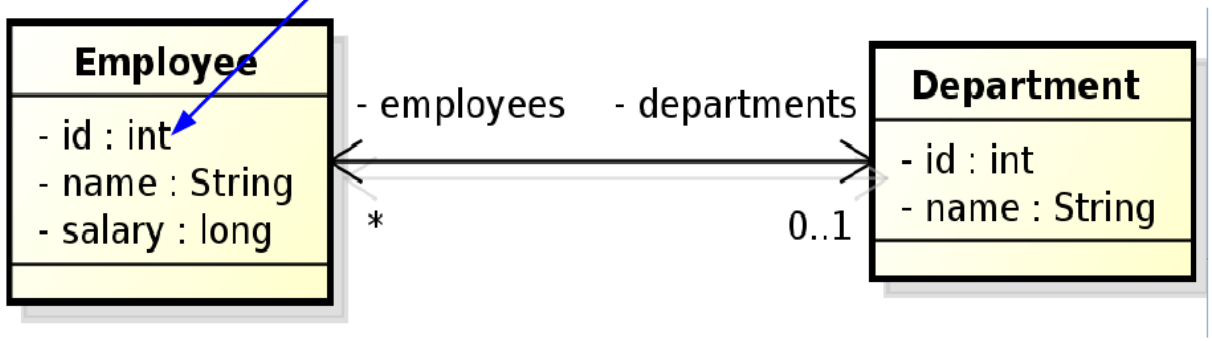


Figure: Entity attribute key

Collection Mapping

```
@Entity
public class Department {
    @Id private int id;
    private String name;
    // …
    @ElementCollection
    @CollectionTable(name="EMP_SENIORITY")
    @MapKeyJoinColumn(name="EMP_ID")
    @Column(name="SENIORITY")
    private Map<Employee, Integer> employees;
    // …
}
```

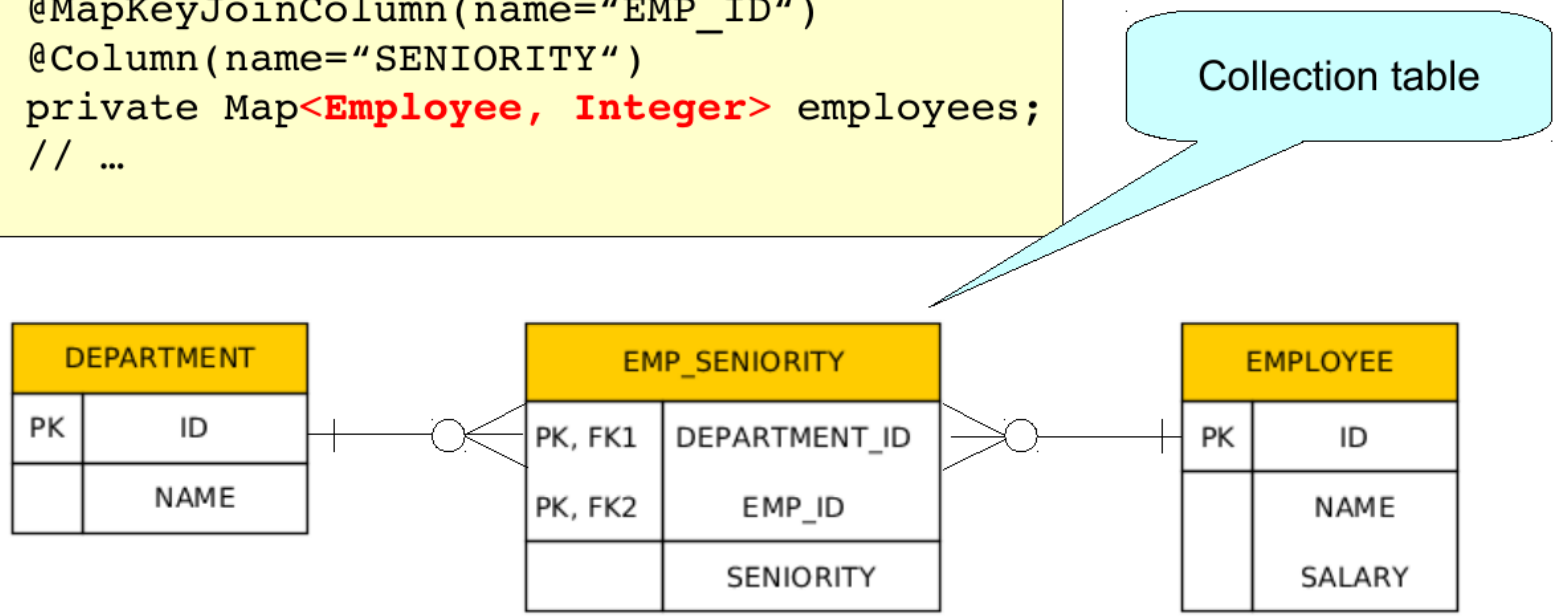
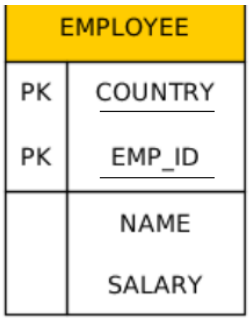


Figure: Entity as a key

Compound and Shared Keys

Compound Primary Keys – `@IdClass`



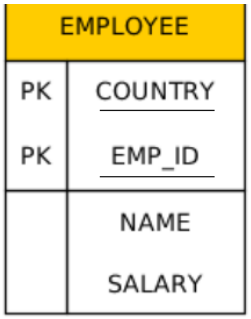

```java
public class EmployeeId
  implements Serializable {
    private String country;
    private Integer id;
}
```

```java
@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:

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

Compound Primary Keys – `@EmbeddedId`




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

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

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

Usage:

```java
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);
```

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 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;
  // ...
}
```

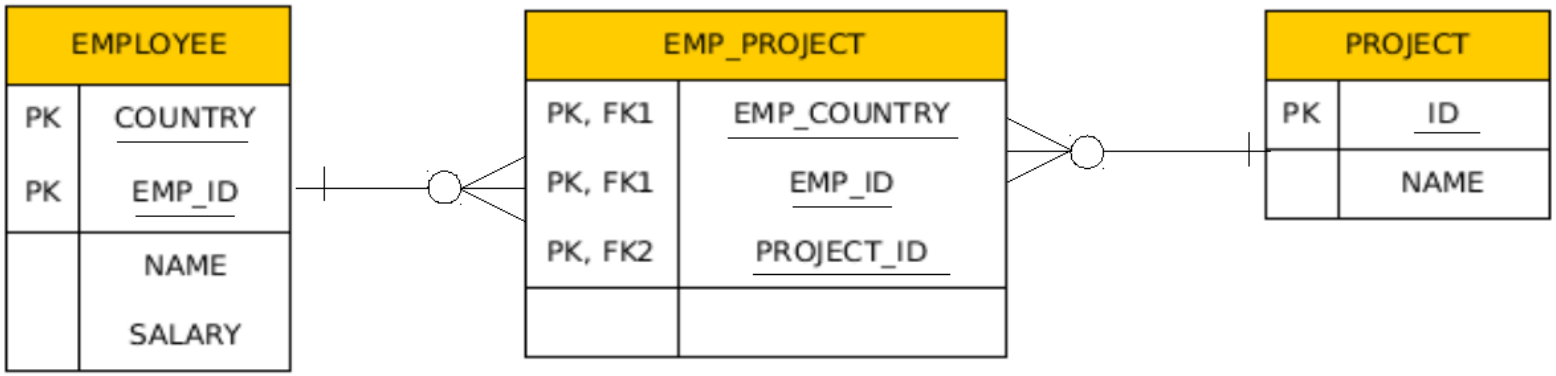
- The primary key in the dependent entity need not be explicitly mapped to an attribute

Compound Join Columns

EMPLOYEE	
PK	COUNTRY
PK	EMP_ID
	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;
    // …
}
```

Compound Join Columns




```
@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;
}
```

Various Attributes and Access Types

Read-only Mapping and Optionality

```
@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

Queries

Queries

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

JPQL

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
```

JPQL – Query Parameters

- 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
```

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();
}
```

JPQL – Named Queries

```
@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 – Bulk Updates

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 fro a relationship, cascading remove occurs.

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

Native (SQL) Queries

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

Mapping is straightforward

Native (SQL) Queries

```
@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)}
```

Native (SQL) Queries

```
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")}
    )
```

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(
  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

```
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++;
}
```

Beyond JPA

Graph Databases

- Comparing to RDBMS – relation types are **first-class citizens**
- Suitable for relaxed data schemas
- Suitable for analytics using graph algorithms
- E.g. Neo4j

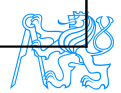
Spring Data Neo4j

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 accesing 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`

The End

Thank You