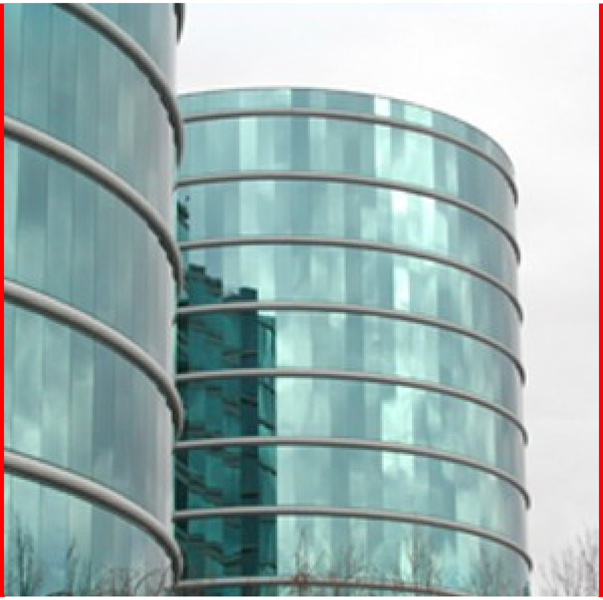

JPA Best Practices

Lee Chuk Munn
chuk-munn.lee@oracle.com

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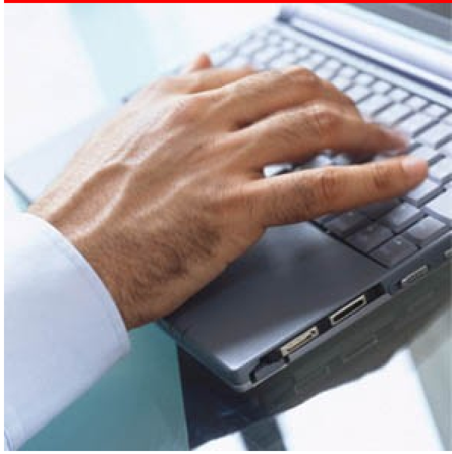
Agenda

- Entities
- EntityManager
- Persistence Context
- Queries
- Transactions



Very Brief Overview of JPA

- Introduced as part of JavaEE 5
- POJO based persistence
  - No interface, convention over configuration, annotation based
- Support rich domain modelling
  - Inheritance and polymorphism
- Query language
- Standardize object/relationship mapping
- Usable in JavaEE and/or JavaSE
  - Unified persistence model across the Java platform

Entities

About Entities

- Are not `EntityBeans` !!!
  - Not threadsafe – not a problem if in JavaEE container
- Are POJOs
  - No remote calls involved, methods are executed locally
- Have states
  - New, managed, detached, removed
- Entities are detached (value objects) outside of transaction context
  - Must merge to update data

Example of an Entity

Annotated as “Entity”

Data are accessed as fields

Maps to “customer” table

```
@Entity(access=FIELD)
@Table(name = “customer”)
public class Customer {
   @Id public int id;
   ...
   public String name;
   @Column(name=”CREDIT”) public int c_rating;

   @LOB public Image photo;
   ...
}
```

@Id denotes primary key

Specify the table
column to map to

Primary Keys

- Annotated with @Id
- Simple use case @Id can be generated
  - TABLE – most portable
  - SEQUENCE, IDENTITY
    - Use database's sequence and/or identity column
    - May not be portable
  - AUTO – let persistence manager pick the best strategy

```
@TableGenerator(name=”mygen”, table=”ID_TABLE”
     , pkColumnName=”GEN_KEY”, pkColumnValue=”EMP_ID”
     , valueColumnName=”GEN_VALUE”)
@Id @GenerateValue(strategy=TABLE, generator=”mygen”)
long id;
```

ID_TABLE

GEN_KEY	GEN_VALUE
EMP_ID	Last generated value

Example – Domain Model

```
@Entity public class Employee {
   @Id private int id;
   private String firstName;
   private String lastName;
   @ManyToOne(fetch=LAZY)
   private Department dept;
        ...
}
@Entity public class Department {
   @Id private int id;
   private String name;
   @OneToMany(mappedBy="dept", fetch=LAZY)
   private Collection<Employee> emps = new ...;
           ...
}
```

Example – Managing Relationship INCORRECT

```
public int addNewEmployee(...) {
   Employee e = new Employee(...);
   Department d = new Department(1, ...);

   e.setDepartment(d);
   //Reverse relationship is not set
   em.persist(e);
   em.persist(d);

   return d.getEmployees().size();
}
```

Example – Managing Relationship CORRECT

```
public int addNewEmployee(...) {
   Employee e = new Employee(...);
   Department d = new Department(1, ...);

   e.setDepartment(d);
   d.getEmployees().add(e);
   em.persist(e);
   em.persist(d);

   return d.getEmployees().size();
}
```

Navigating Relationships

- Data fetching strategy
  - EAGER – immediate
  - LAZY – load only when needed
- Lazy is good for large objects with deep relationship hierarchies
- Eager is automatic when operation is performed outside of a transaction
  - Entities are detached immediately
- Cascade specifies operations on relations
  - ALL, PERSIST, MERGE, REMOVE, REFRESH
  - Default is to do nothing
- Avoid MERGE with deep hierarchies
  - Or limit the scope of merge

Choosing Between EAGER and LAZY

- EAGER – too many joins

```
SELECT d.id, ..., e.id, ...
  FROM Department d left join fetch Employee e
      on e.deptid = d.id
```

- LAZY – N + 1

```
SELECT d.id, ... FROM Department d // 1 time
SELECT e.id, ... FROM Employee e
     WHERE e.deptId = ? // N times
```

Lazy Loading

- Lazy load fields and relationships that are not used frequently
- One-many/many-may relationships are lazy loaded by default
- Lazy load CLOB/BLOB if possible

LAZY Loading and Value Objects

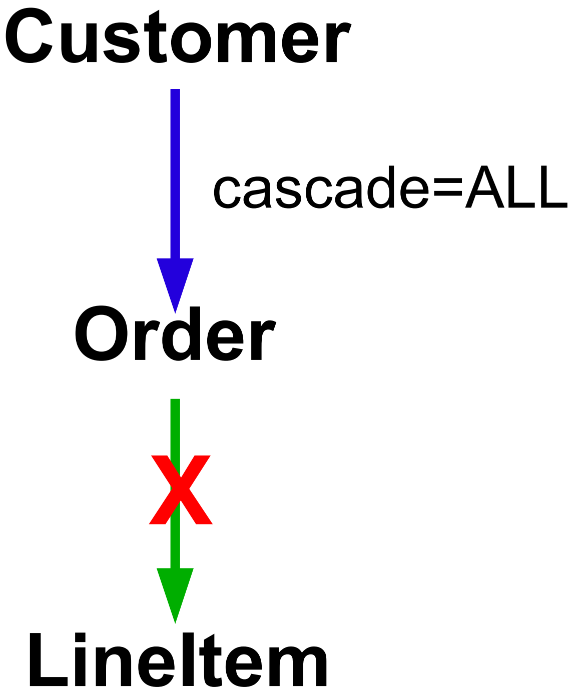
- Accessing a LAZY relationship from a detached entity
  - May get a null
  - May get a previously cached value
  - May get an exception
- Use JOIN FETCH for such objects
  - Specifying which field to pre-fetch – fetcy is like EAGER
  - Returns only Employees that matches WHERE

```
SELECT d FROM Department d
  JOIN FETCH d.employees WHERE ...
```

- Access the collection before entity is detached
    - Like a sync

```
//Forces all employees to be loaded
d.getEmployees().size();
```

Using Cascade



Customer

cascade=ALL

Order

X

LineItem

```
public class Customer {
   @OneToMany(cascase=ALL,
        mappedby="customer")
   Set<Order> orders;


public class Order {
   @ManyToOne
   Customer customer;
   @OneToMany(mappedBy="order")
   List<LineItem> lineItems;


public class LineItem {
   @OneToMany
   Order order
```

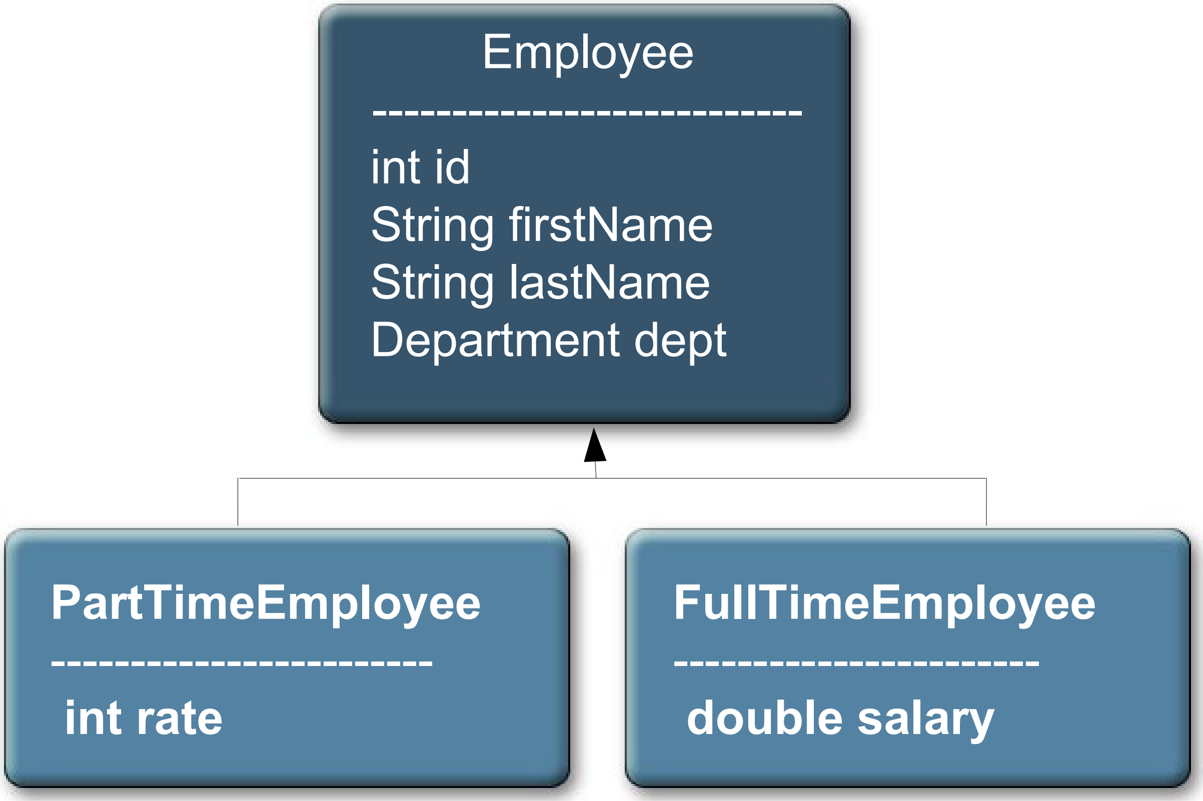
Cascade in Model or Schema

- Much faster as foreign key constraint but less apparent to developer

In Oracle PL/SQL

```
create table employee (
  ...
  constraint fk_dept_id
      foreign key (dept_id)
      references department(dept_id)
      on delete cascade
  ...
}
```

Mapping Inheritance



Employee

----

int id

String firstName

String lastName

Department dept

PartTimeEmployee

----

int rate

FullTimeEmployee

----

double salary

Single Table Per Class

- Benefits
  - Simple
  - No joins
- Drawbacks
  - Not normalized
  - Requires a discriminator field for subclass
  - Table may have too many columns

```
              EMPLOYEE
     ---------------------------
ID                   Int PK,
FIRSTNAME            varchar(255),
LASTNAME             varchar(255),
DEPT_ID              int FK,
RATE                 int NULL,
SALARY               double NULL,
DISCRIM              varchar(30)
```

```
@Inheritance(strategy=SINGLE_TABLE)
```

Joined Subclass

- Benefits
  - Normalized database
  - Database view same as domain model
  - Easy to evolve domain model
- Drawbacks
  - Poor performance in deep hierarchies
  - Poor performance for polymorphic queries and relationships

EMPLOYEE

ID	int PK,
FIRSTNAME	varchar(255),
LASTNAME	varchar(255),
DEPT_ID	int FK,
DISCRIM	varchar(30)

PARTTIMEEMPLOYEE

ID	int PK FK,
RATE	int NULL

FULLTIMEEMPLOYEE

ID	int PK FK,
SALARY	
double NULL	

```
@Inheritance(strategy=JOINED)
```

Table Per Class

- Benefits
  - No need for joins if only leaf class are entities
- Drawbacks
  - Not normalized
  - Poor performance when querying non-leaf entities-union
  - Poor support for polymorphic relationships
- This is not mandatory in the specs

EMPLOYEE	
ID	int PK,
FIRSTNAME	varchar(255),
LASTNAME	varchar(255),
DEPT_ID	int FK

PARTTIMEEMPLOYEE	
ID	int PK,
FIRSTNAME	varchar(255),
LASTNAME	varchar(255),
DEPT_ID	int FK,
RATE	int NULL

FULLTIMEEMPLOYEE	
ID	int PK,
FIRSTNAME	varchar(255),
LASTNAME	varchar(255),
DEPT_ID	int FK,
SALARY	double NULL

```
@Inheritance(strategy=TABLE_PER_CLASS)
```

Entity Manager

Container vs Application

- Container managed entity manager
  - Injected into application
  - Automatically closed
  - JTA transaction – propagated
- Application managed entity managers
  - Used outside of the JavaEE 5 platform
  - Need to be explicitly created
    - `Persistence.createEntityManagerFactory()`
  - RESOURCE_LOCAL transactions
    - Not propagated
  - Need to explicitly close

Threading Model and Injections

- JPA components
  - EntityManager is not threadsafe
  - EntityManagerFactory is threadsafe
- Field injection is only supported for instance variable
  - Not threadsafe
- Dangerous to inject non threadsafe objects into stateless components
  - Inconsistent data
  - Data viewable by other threads

Injecting EntityManagers

```
public class ShoppingCartServlet extends HttpServlet {
  @PersistenceContext EntityManager em;
  protected void doPost(HttpServlet req, ...) {
    Order order order = ...;
    em.persist(order);
  }
```

WRONG

```
public class ShoppingCartServlet extends HttpServlet {
  @PersistenceUnit EntityManagerFactory factory;
  protected void doPost(HttpServlet req, ...) {
    EntityManager em = factory.createEntityManager();
    Order order order = ...;
    em.persist(order);
  }
```

CORRECT

Persistence Context

Persistence Context

- Acts like a cache for entities
- Two types of persistence context
- Transaction scoped
  - Used in stateless components
  - Typically begins/ends at method entry/exit points
- Extended scoped persistence context
  - Used with business transactions spans multiple request
  - Ideal place is to create extended PC at the beginning of business process or session
  - Supported in
    - `StatefulSessionBean`
    - Application managed `EntityManager`

Persistence Context and Caching

```
String empId = “12345”;
. . .
```

Meanwhile empId 12345 have been changed **in another thread**

```
//Query the data
Query query = em.createQuery(“SELECT e FROM Employee e “
     + “WHERE e.ID = :ID”).setParameter(“ID”, empId);
employee = (Employee)query.getSingleResult();
```

Will I get the new data for employee?

Persistence Context as Cache

- It depends
- Entities managed by persistence context
  - Are not refreshed from database until `EntityManager.refresh()` is invoked
  - Are not synchronized with database until `EntityManager.flush()` is explicitly invoked or implicitly when PC closes
- Entities remains managed by PC until
  - `EntityManager.clear()` is invoked
  - Transaction commits

Flush Mode

- Controls whether the state of managed entities are synchronized before a query
- Types of flush mode
  - AUTO – immediate, default
  - COMMIT – flush only when a transaction commits
  - NEVER – need to invoke `EntityManager.flush()` to flush
- Querying data you know that has not change or don't care if result includes changes, set flush to COMMIT

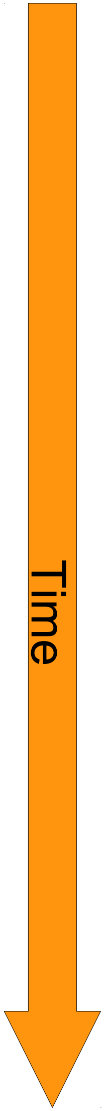
```
Query q = em.createNamedQuery(“findAllOrders”);
q.setParameter(“id”, orderNumber);
q.setFlushMode(FlushModeType.AUTO);
//Ensure that the query gets the latest results
List list = q.getResultList();
```

Stale Data and Parallel Updates

- JPA simplifies persistence but does not guard against parallelism
- Introduce `@Version` for optimistic locking
  - Can be `int`, `Integer`, `short`, `Short`, `long`, `Long`, `Timestamp`
  - Not used by application
  - Updated when transaction commits, merged or acquiring a write lock

```
public class Employee {
  @ID int id;
  @Version Timestamp timestamp;
  ...
```

Preventing Parallel Updates – 1

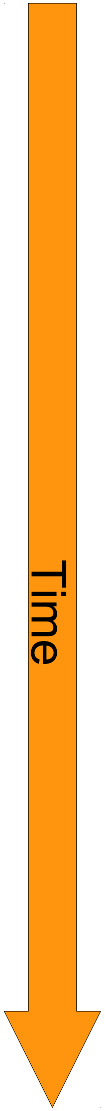


```
tx1.begin();                  tx2.begin();
//Joe's employee id is 5      //Joe's employee id is 5
//e1.version == 1             //e1.version == 1
e1 = findPartTimeEmp(5);      e1 = findPartTimeEmp(5);
                              //Series of expensive
//Current rate is $9          //to follow
e1.raiseByTwoDollar();
//Current rate is $11



tx1.commit();
//e1.version == 2 in db
                              //e1.version == 1 in db?
                              tx2.commit();
                              ~~//Joe's rate will be $14~~
                              //OptimisticLockException
```

Preventing Parallel Updates – 2



```
tx1.begin();
//Joe's employee id is 5
//e1.version == 1
e1 = findPartTimeEmp(5);

//Current rate is $9
e1.raiseByTwoDollar();
//Current rate is $11



tx1.commit();
//e1.version == 2 in db
```

```
tx2.begin();
//Joe's employee id is 5
//e1.version == 1
e1 = findPartTimeEmp(5);
em.lock(d1, WRITE);
//version++ for d1
em.flush();
//Series of expensive
//to follow


//e1.version == 1 in db?
tx2.commit();
~~//Joe's rate will be $14~~
//OptimisticLockException
```

Lock Modes

- Five lock modes
  - OPTIMISTIC – provides repeatable read isolation
  - OPTIMISTIC_FORCE_INCREMENT – repeatable read but updates version field
  - PESSIMISTIC_READ – pessimistic repeatable read
  - PESSIMISTIC_WRITE – serialized access
  - PESSIMISTIC_FORCE_INCREMENT – pessimistic but also updates version field, optional
- OPTIMISTIC and OPTIMISTIC_FORCE_INCREMENT are the new names for READ and WRITE respectively

Bulk Updates

- Update directly against the database
  - By passes `EntityManager`
  - `@Version` will not be updated
  - Entities in persistence context may be outdated
- Avoid updating individual entities
  - Use bulk updates

SLOW

```
//Terminate all contract employees
List<Employee> empList = query.getResultList();
for (Employee e: empList)
   e.status(“ContractEnd”);
```

Generate lots of SQL

FAST

```
//Terminate all contract employees
TypedQuery<Employee> query = em.createQuery(
     “UPDATE Employee e SET i.status = 'ContractEnd'
     + “WHERE ...”);
query.executeQuery();
```

Queries

Queries

- Prefix query names with class being returned (JPA 1)

```
@NamedQuery(name="Employee.findByName", ...)
```

- Dynamic query
  - Beware of SQL injection, better to use with named parameters
  - Use named query instead of dynamic query where possible – enforce parametrized query

```
q = em.createQuery("select e from Employee e WHERE "
     + "e.empId LIKE '" + id + "'");
```

NOT GOOD

```
q = em.createQuery("select e from Employee e WHERE "
     + "e.empId LIKE ':id'");
q.setParameter("id", id);
```

GOOD

Typed Queries

- Specify the type that the query will return
  - Works with named, native and dynamic queries
- Alternatively, use criteria – same effect

```
TypedQuery<Employee> q = em.createQuery(
    “select e from Employee e WHERE ”
    + “e.empId LIKE ':id'”, Employee.class);
q.setParameter(“id”, id);

List<Employee> list = q.getResultList();
```

Polymorphic Queries

- May return too many results
  - Eg. Employee → PartTime, FullTime, Intern – return 2 of 3
- Use type expression to restrict query polymorphism

```
select e from Employee e
    where type(e) in (PartTime, Intern)
```

Criteria API

- Currently JPQLs are string based
  - Easier to use but not cannot perform compile time checking on query and entity attribute name typos
- Dynamically creates query without out string manipulation
  - Parity with string based query
- Strongly type, compiler validation during development
- Optionally can generate metamodel over entities
  - Provided by ORM tools

JPA Queries

“*SELECT o FROM ORDER o WHERE o.total > 100*”

OK

```
CriteriaBuilder cb = em.getCriteriaBuilder();
CriteriaQuery<Order> o = cb.createQuery(Order.class);
Root<Order> ord = o.from(Order.class);
Predicate cond = cb.gt(ord.get(“total”), 100);
o.select(ord).where(cond);
TypeQuery<Order.class> q = en.createQuery(o);
List<Person> result = q.getResultList();
```

BETTER

```
CriteriaQuery<Order> o = cb.createQuery(Order.class);
Root<Order> ord = o.from(Order.class);
o.select(ord).where(cb.gt(ord.get(Order_.total), 100));
TypeQuery<Order.class> q = en.createQuery(o);
List<Person> result = q.getResultList();
```

BEST

Generated metamodel

Transactions

Transactions

- Do not perform expensive and unnecessary operations that are not part of a transaction
  - Hurt performance, eg. logging
- Keep the code in the transaction to a minimum and close it when not needed
- Eliminate transaction for “read-only” data
  - Eg. Department names

```
@Stateless public ... {
  @TransactionAttribute(NOT_SUPPORTED)
  public List<Deparment> getAllDepartments() {
    return (em.createQuery(
         “SELECT e FROM Department e”)
         .getResultList());
  }
```

Transaction Type

- Container managed EntityManager can be JTA or `RESOURCE_LOCAL`
  - `RESOURCE_LOCAL` is non JTA
- `RESOURCE_LOCAL` `EntityManager` are created from `EntityManagerFactory`

JTA From Non JTA `EntityManager`

- Create `EntityManager` inside a JTA transaction
  - Get an injected instance of JTA from container or client container (for JavaSE)

```
@Resource UserTransaction utx;
. . .
utx.begin();
EntityManager em = emf.createEntityManager();
//em is now JTA
```

- Join a JTA transaction

```
@Resource UserTransaction utx;
. . .
EntityManager em = emf.createEntityManager();
//em is is RESOURCE_LOCAL
utx.begin();
em.joinTransaction();
```

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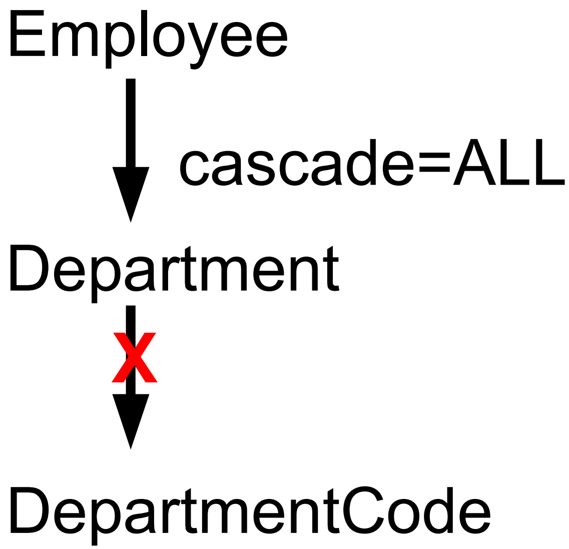
Using Cascade

```
@Entity public class Employee {
  @Id private int id;
  private String firstName;
  private String lastName;
  @ManyToOne(cascade=MERGE, fetch=LAZY)
  private Department dept;
      ...
}
@Entity public class Department {
  @Id private int id;
  private String name;
  @OneToMany(mappedBy = "dept"
            cascade=MERGE, fetch=LAZY)
  private Collection<Employee> emps = new ...;
  @OneToMany
  private Collection<DepartmentCode> codes;
        ...
 }
```



Employee

cascade=ALL

Department

X

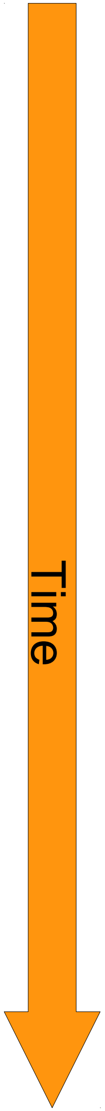
DepartmentCode

Transient Fields

- Used on fields that are not persisted
  - Eg. computed fields, temporary values, cached values

```
@Entity public class Employee {
   @Id private int id;
   private String firstName;
   private String lastName;
   @ManyToOne(fetch=LAZY)
   private Department dept;
   @Transient float yearEndBonus = 0f;
       ...
}
```

Preventing Stale Data

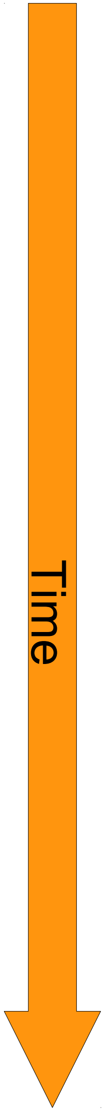


```
tx1.begin();                        tx2.begin();
d1 = findDepartment(dId);
                                    e1 = findEmp(eId);
//d1's original name is             d1 = e1.getDepartment();
//”Engrg”                           em.lock(d1, READ);
d1.setName(“MarketEngrg”);          if(d1's name is “Engrg”)
                                       e1.raiseByTenPercent();
tx1.commit();




                                    //Check d1.version in db
                                    tx2.commit();
                                    ~~//e1 gets the raise he does~~
                                    ~~//not deserve~~
                                    //Transaction rolls back
```

Pessimistic Locks on Update



```
tx1.begin();
e1 = findDepartment(dId);
em.lock(e1, PESSIMISTIC_WRITE);




//d1's original name is
//”Engrg”
d1.setName(“MarketEngrg”);

tx1.commit();
```

```
tx2.begin();
props.put(“javax.persistance
.lock.timeout”, 5000);
e1 = findEmp(eId);
//Continue or timeout
em.lock(e1
, PESSIMISTIC_WRITE, props);
```