UNIVERSITY OF TECHNOLOGY SYDNEY
Faculty of Information Technology

Advanced Java programming (Java EE)

Java Persistence API

Based on the JPA presentation from javabeat.net

Topics

UNIVERSITY OF TECHNOLOGY SYDNEY
Faculty of Information Technology

- **Introduction to java persistence**
- The Java Persistence API
  - Entities
  - EntityManager & the Persistent Context
  - Persistence Units
  - Exceptions
  - JPA Query Language

Introduction

UNIVERSITY OF TECHNOLOGY SYDNEY
Faculty of Information Technology

- 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

UNIVERSITY OF TECHNOLOGY SYDNEY
Faculty of Information Technology

- 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

Java EE to the rescue

UNIVERSITY OF TECHNOLOGY SYDNEY
Faculty of Information Technology

- 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

Java EE 5 persistence

UNIVERSITY OF TECHNOLOGY SYDNEY
Faculty of Information Technology

- Java EE 5 still keeps JDBC
- EJB 3 spec (JSR 220) split into 2:
  1. Session Beans, Message Beans
  2. Java Persistence API (JPA)

- JPA jointly developed by TopLink, Hibernate, JDO, EJB vendors and individuals

- JPA can also be used in Java SE 5 without a container!!!!

Java Persistence

UNIVERSITY OF TECHNOLOGY SYDNEY
Faculty of Information Technology

- Java Persistence consists of three areas:
  - The Java Persistence API
  - The query language
  - Object/relational mapping metadata

- JPA implementation
  - Reference implementation: TopLink (GlassFish project)
  - Most ORM vendors now have JPA interface
    - eg: Hibernate-JPA, EclipseLink (based on TopLink), OpenJPA (based on BEA Kodo)

Topics

UNIVERSITY OF TECHNOLOGY SYDNEY
Faculty of Information Technology

- Introduction to java persistence
- **The Java Persistence API**
  - **Entities**
  - EntityManager & the Persistent Context
  - Persistence Units
  - Exceptions
  - JPA Query Language

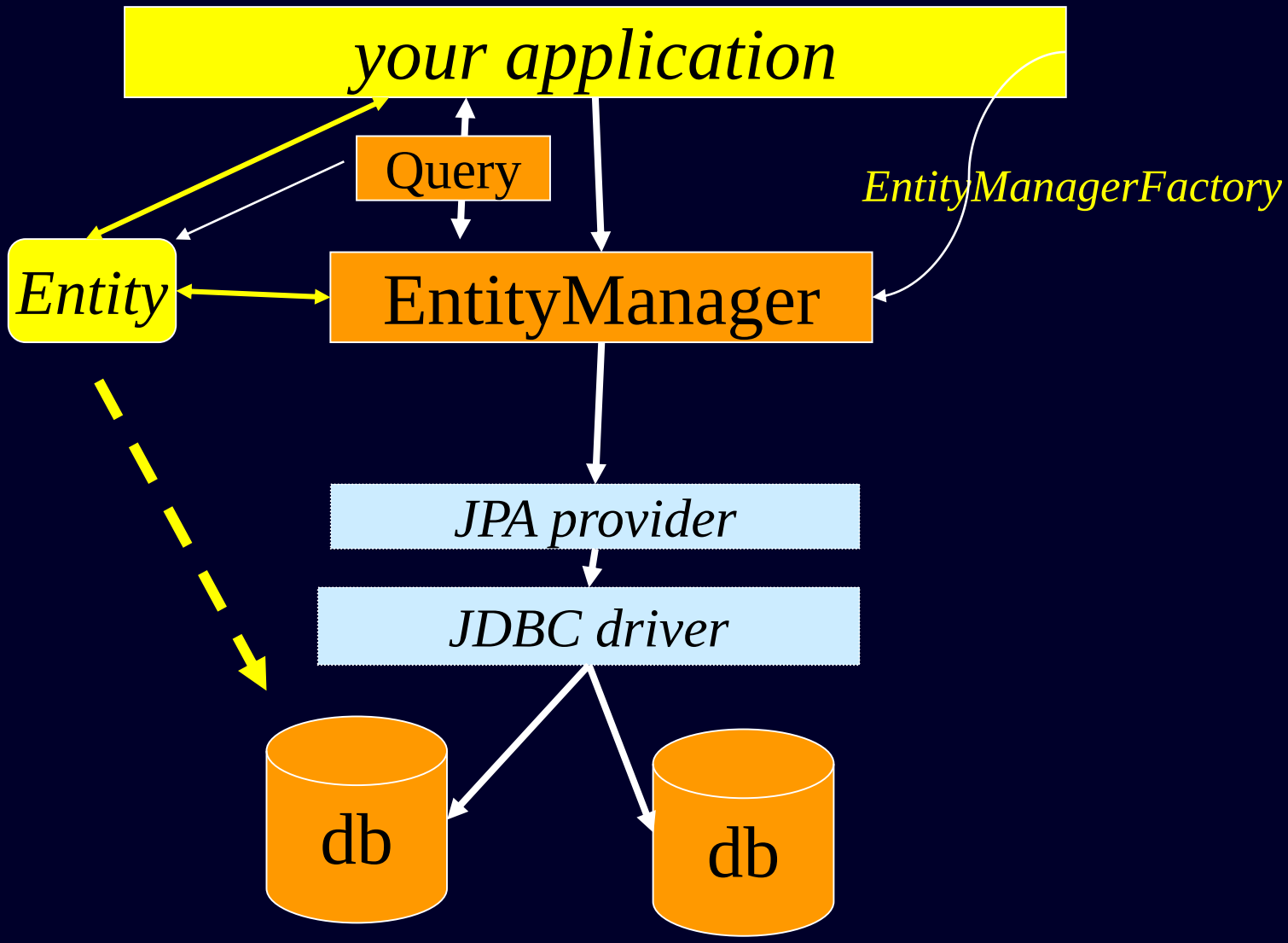
Java Persistence API

UNIVERSITY OF TECHNOLOGY SYDNEY
Faculty of Information Technology

- javax.persistence.*
  - EntityManager
  - EntityManagerFactory
  - EntityTransaction
  - Query
  - "*Entity*" – we use Plain Old Java Objects (POJO) instead.

JPA classes

UNIVERSITY OF TECHNOLOGY SYDNEY
Faculty of Information Technology



Entities

UNIVERSITY OF TECHNOLOGY SYDNEY
Faculty of Information Technology

- 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 constructor
  - the class must not be declared `final`
  - no methods or persistent instance variables must be declared `final`

Requirements for Entities (cont.)

UNIVERSITY OF TECHNOLOGY SYDNEY
Faculty of Information Technology

- 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
- No required business/callback interfaces
- Example:

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

Persistent Fields and Properties

UNIVERSITY OF TECHNOLOGY SYDNEY
Faculty of Information Technology

- 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

UNIVERSITY OF TECHNOLOGY SYDNEY
Faculty of Information Technology

- 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;
}
        . . .
}
```

Primary key

Persistent Identity

UNIVERSITY OF TECHNOLOGY SYDNEY
Faculty of Information Technology

- 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

UNIVERSITY OF TECHNOLOGY SYDNEY
Faculty of Information Technology

- 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

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

Customizing the Entity Object

UNIVERSITY OF TECHNOLOGY SYDNEY
Faculty of Information Technology

- 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

UNIVERSITY OF TECHNOLOGY SYDNEY
Faculty of Information Technology

- 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

UNIVERSITY OF TECHNOLOGY SYDNEY
Faculty of Information Technology

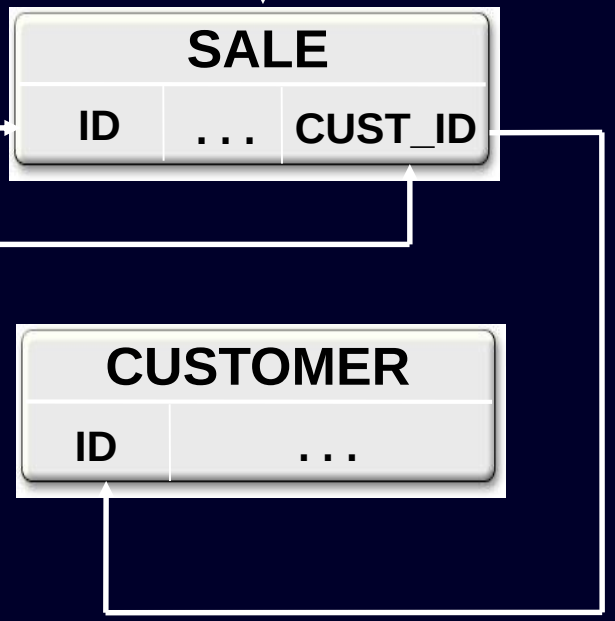
- JPA supports cascading updates/deletes
  - CascadeType
    - **ALL, PERSIST, MERGE, REMOVE, REFRESH**
- You can declare performance strategy to use with fetching related rows
  - FetchType
    - **LAZY, EAGER**
      - (Lazy means don't load row until the property is retrieved)

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

ManyToOne Mapping

UNIVERSITY OF TECHNOLOGY SYDNEY
Faculty of Information Technology

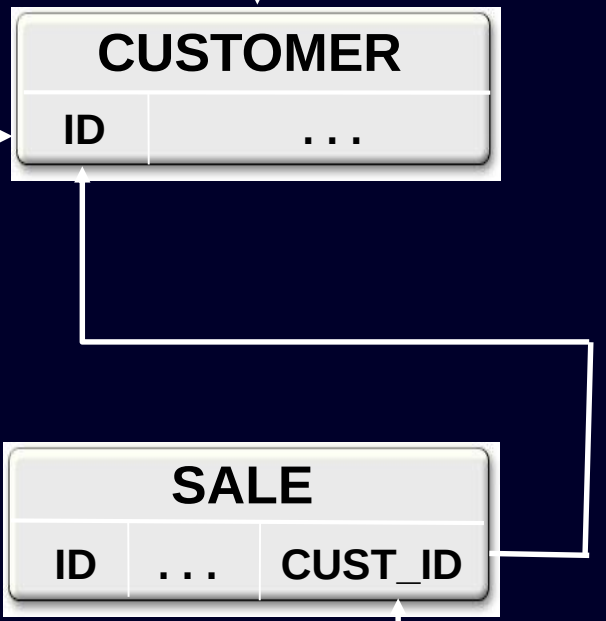
```
@Entity
public class Sale {
    @Id
    int id;

    ...
    @ManyToOne
    Customer cust;
}
}
```



OneToMany Mapping

UNIVERSITY OF TECHNOLOGY SYDNEY
Faculty of Information Technology

```
@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

UNIVERSITY OF TECHNOLOGY SYDNEY
Faculty of Information Technology

```
@Entity
public class Customer {
   ...
   @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;
}
```

Entity Inheritance

UNIVERSITY OF TECHNOLOGY SYDNEY
Faculty of Information Technology

- An important capability of the JPA is its support for inheritance and polymorphism
- Entities can inherit from other entities and from non-entities
- The `@Inheritance` annotation identifies a mapping strategy:
  - SINGLE_TABLE
  - JOINED
  - TABLE_PER_CLASS

Inheritance Example

UNIVERSITY OF TECHNOLOGY SYDNEY
Faculty of Information Technology

```
@Entity
@Inheritance(strategy=InheritanceType.SINGLE_TABLE)
@DiscriminatorColumn(name="DISC",
                     discriminatorType=DiscriminatorType.STRING)
@DiscriminatorValue(name="CUSTOMER")
public class Customer { . . . }

@Entity
@DiscriminatorValue(name="VCUSTOMER")
public class ValuedCustomer extends Customer { . . . }
```

- SINGLE_TABLE strategy - all classes in the hierarchy are mapped to a single table in the database
- Discriminator column - contains a value that identifies the subclass
- Discriminator type - {STRING, CHAR, INTEGER}
- Discriminator value - value entered into the discriminator column for each entity in a class hierarchy

Topics

UNIVERSITY OF TECHNOLOGY SYDNEY
Faculty of Information Technology

- Introduction to java persistence
- The Java Persistence API
  - Entities
  - **EntityManager & the Persistent Context**
  - Persistence Units
  - Exceptions
  - JPA Query Language

Managing Entities

UNIVERSITY OF TECHNOLOGY SYDNEY
Faculty of Information Technology

- 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

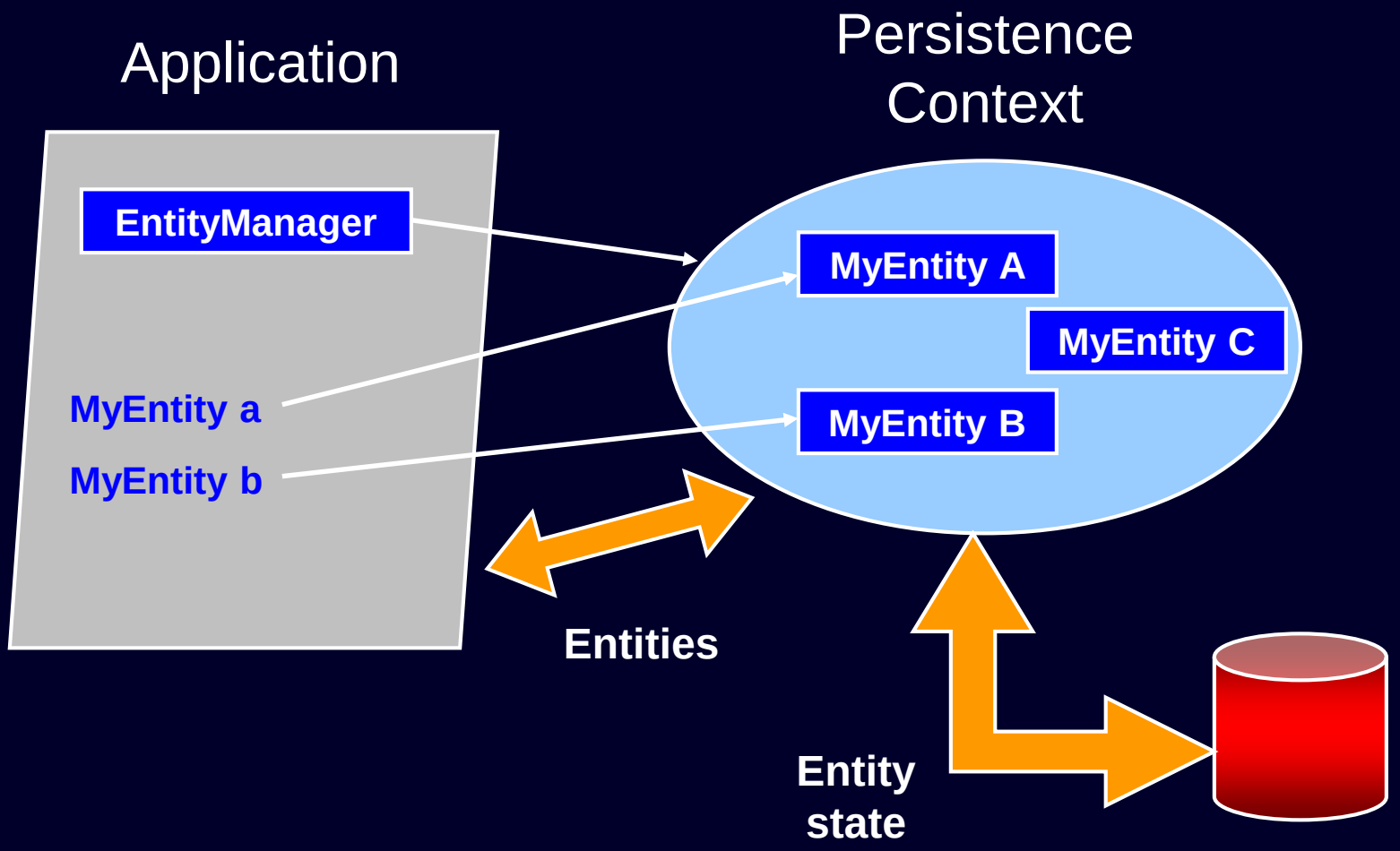
Persistence Context

UNIVERSITY OF TECHNOLOGY SYDNEY
Faculty of Information Technology

- 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

UNIVERSITY OF TECHNOLOGY SYDNEY
Faculty of Information Technology



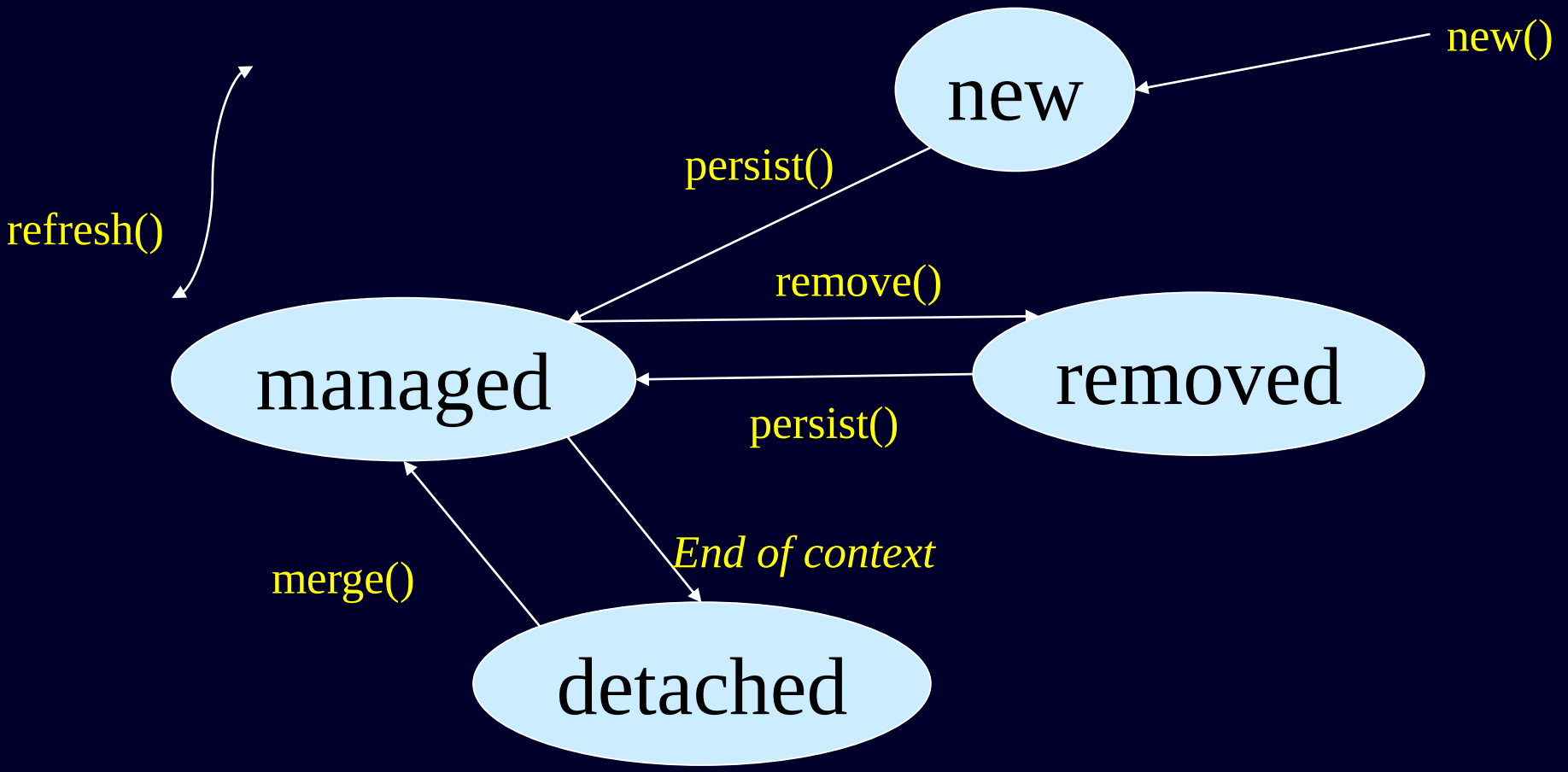
Entity Manager

UNIVERSITY OF TECHNOLOGY SYDNEY
Faculty of Information Technology

- 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

UNIVERSITY OF TECHNOLOGY SYDNEY
Faculty of Information Technology



Entity Lifecycle

UNIVERSITY OF TECHNOLOGY SYDNEY
Faculty of Information Technology

- 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

Entity Manager

UNIVERSITY OF TECHNOLOGY SYDNEY
Faculty of Information Technology

- 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: Tomcat

Application-Managed EntityManager

UNIVERSITY OF TECHNOLOGY SYDNEY
Faculty of Information Technology

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

Application-Managed EntityManager

UNIVERSITY OF TECHNOLOGY SYDNEY
Faculty of Information Technology

- Applications must manage own transactions too..

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

Container-Managed EntityManager

UNIVERSITY OF TECHNOLOGY SYDNEY
Faculty of Information Technology

- Containers provide naming and transaction services for JPA
  - (eg: Web Container like Tomcat, EJB Container like WebLogic)
- JPA relies on the container to insert the actual reference to the EntityManager for the current context via ***dependency injection***
- Use the Java5 annotations to do this

Container-Managed EntityManagers

UNIVERSITY OF TECHNOLOGY SYDNEY
Faculty of Information Technology

- An EntityManager with a transactional persistence context can be **injected** by using the `@PersistenceContext` annotation

```
@PersistenceContext (unitName="SomePUnit")
    EntityManager em;
// Perform finds, execute queries,
…
// update entities, etc.
em.close();
```

container inserts reference to the container's EntityManager

- You could also use the @Resource(name="jndi:name") annotation to insert a named entity manager.

Transactions

UNIVERSITY OF TECHNOLOGY SYDNEY
Faculty of Information Technology

- JPA transactions can be managed by:
  - the users application
  - a framework (such as Spring)
  - a Java EE container
- Transactions can be controller in two ways:
  - Java Transaction API (JTA)
    - container-managed entity manager
  - EntityTransaction API (`tx.begin(), tx.commit(), etc`)
    - application-managed entity manager

Operations on Entity Objects

UNIVERSITY OF TECHNOLOGY SYDNEY
Faculty of Information Technology

- 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

Topics

UNIVERSITY OF TECHNOLOGY SYDNEY
Faculty of Information Technology

- Introduction to java persistence
- The Java Persistence API
  - Entities
  - EntityManager & the Persistent Context
  - **Persistence Units**
  - Exceptions
  - JPA Query Language

Persistence Units

UNIVERSITY OF TECHNOLOGY SYDNEY
Faculty of Information Technology

- 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 `persistence.xml` configuration file

persistence.xml

UNIVERSITY OF TECHNOLOGY SYDNEY
Faculty of Information Technology

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

```
<persistence>
   <persistence-unit name="SomePUnit">
     <provider>org.hibernate.ejb.HibernatePersistence</provider>
     <class>myapp.MyEntity</class>
     <properties>
           <property name="hibernate.connection.url"
          value="jdbc:oracle:thin:@smaug.it.uts.edu.au:1522:ell"/>
        <property name="hibernate.connection.driver_class"
          value="oracle.jdbc.driver.OracleDriver"/>
        <property name="hibernate.connection.username"
                value="user"/>
        <property name="hibernate.connection.password"
                value="password"/>
  </persistence-unit>
</persistence>
```

persistence.xml

UNIVERSITY OF TECHNOLOGY SYDNEY
Faculty of Information Technology

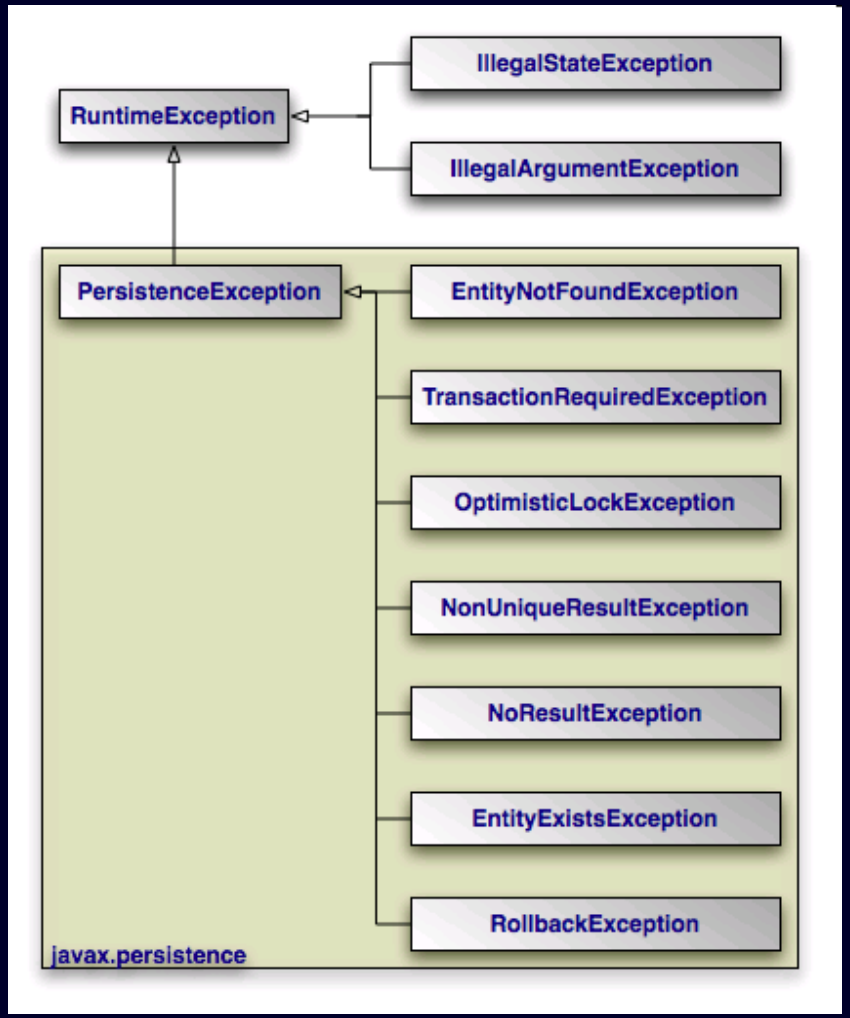
You can also use JNDI + datasource in **`persistence.xml`** instead of hard coding driver details. Requires container to manage this.

```
<persistence>
    <persistence-unit name=" SomePUnit">
     <provider>org.hibernate.ejb.HibernatePersistence</provider>
      <jta-data-source>jdbc/thinOracleDataSource</jta-data-source>
      <class>myapp.MyEntity</class>
    </persistence-unit>
</persistence>
```

JPA exceptions

UNIVERSITY OF TECHNOLOGY SYDNEY
Faculty of Information Technology

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



http://openjpa.apache.org/docs/openjpa-0.9.0-incubating/manual/manual.html

Topics

UNIVERSITY OF TECHNOLOGY SYDNEY
Faculty of Information Technology

- Introduction to java persistence
- The Java Persistence API
  - Entities
  - EntityManager & the Persistent Context
  - Persistence Units
  - Exceptions
  - **JPA Query Language**

JPQL Introduction

UNIVERSITY OF TECHNOLOGY SYDNEY
Faculty of Information Technology

- 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

UNIVERSITY OF TECHNOLOGY SYDNEY
Faculty of Information Technology

- 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

UNIVERSITY OF TECHNOLOGY SYDNEY
Faculty of Information Technology

- 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="findAllCustomers",
            query="SELECT c FROM Customer")
```

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

Multiple Named Queries

UNIVERSITY OF TECHNOLOGY SYDNEY
Faculty of Information Technology

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

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

Dynamic Queries

UNIVERSITY OF TECHNOLOGY SYDNEY
Faculty of Information Technology

- 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

UNIVERSITY OF TECHNOLOGY SYDNEY
Faculty of Information Technology

- 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

UNIVERSITY OF TECHNOLOGY SYDNEY
Faculty of Information Technology

- 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

UNIVERSITY OF TECHNOLOGY SYDNEY
Faculty of Information Technology

- 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

UNIVERSITY OF TECHNOLOGY SYDNEY
Faculty of Information Technology

- `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

UNIVERSITY OF TECHNOLOGY SYDNEY
Faculty of Information Technology

- 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

UNIVERSITY OF TECHNOLOGY SYDNEY
Faculty of Information Technology

```
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

UNIVERSITY OF TECHNOLOGY SYDNEY
Faculty of Information Technology

- 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()

JPQL Statement Language

UNIVERSITY OF TECHNOLOGY SYDNEY
Faculty of Information Technology

- JPQL statement types:
  - SELECT, UPDATE, DELETE
- Supported clauses:
  - FROM
  - WHERE
  - GROUP_BY
  - HAVING
  - ORDER BY
  - …
- Conditional expressions, aggregate functions,…

JPQL Enhancements over EJBQL 2.x

UNIVERSITY OF TECHNOLOGY SYDNEY
Faculty of Information Technology

- Simplified query syntax
- JOIN operations
- Group By and Having Clause
- Subqueries
- Dynamic queries
- Named parameters
- Bulk update and delete

OO-style vs. SQL-style queries

UNIVERSITY OF TECHNOLOGY SYDNEY
Faculty of Information Technology

- The main difference:
  *** query the application model, i.e. the entities, rather than any database tables
- Better productivity by using OO-style queries, e.g.

```
employee.getManager().getAddress()
```

which becomes:

```
SELECT t3.* FROM EMP t1, EMP t2, ADDR t3
WHERE t1.EMP_ID = "XYZ" AND t1.MGR_ID = t2.EMP_ID
AND t2.ADDR_ID = t3.ADDR_ID
```

- Notice that the two-step object traversal was packed into a single DB query

Questions?

UNIVERSITY OF TECHNOLOGY SYDNEY
Faculty of Information Technology

Resources

UNIVERSITY OF TECHNOLOGY SYDNEY
Faculty of Information Technology

- The Java Persistence API - A Simpler Programming Model for Entity Persistence
  `http://java.sun.com/developer/technicalArticles/J2EE/jpa/`
- Article "Introduction to Java Persistence API"
  `http://www.javabeat.net/javabeat/ejb3/articles/2007/04/introduction_to_java_persistence_api_jpa_ejb_3_0_1.php`
- TopLink Essentials (reference implementation)
  `https://glassfish.dev.java.net/javaee5/persistence/`
- JPA Annotation Reference
  `http://www.oracle.com/technology/products/ias/toplink/jpa/resources/toplink-jpa-annotations.html`

Resources

UNIVERSITY OF TECHNOLOGY SYDNEY
Faculty of Information Technology

- JPQL Language Reference
  `http://openjpa.apache.org/builds/1.0.2/apache-openjpa-1.0.2/docs/manual/jpa_langref.html`
- JPA Query API
  `http://www.javabeat.net/javabeat/ejb3/articles/2007/04/introduction_to_java_persistence_api_jpa_ejb_3_0_6`
- Standardizing Java Persistence with the EJB3 Java Persistence API – Query API
  `http://www.onjava.com/pub/a/onjava/2006/05/17/standardizing-with-ejb3-java-persistence-api.html?page=last&x-showcontent=text`