Hibernate / JPA Overview

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Topics

- What is Hibernate?
- Benefits of Hibernate
- What is JPA?
- Benefits of JPA
- Code Snippets

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What is Hibernate?

- A framework for persisting / saving Java objects in a database
  - www.hibernate.org/orm

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Benefits of Hibernate

- Hibernate handles all of the low-level SQL
- Minimizes the amount of JDBC code you have to develop
- Hibernate provides the Object-to-Relational Mapping (ORM)

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Object-To-Relational Mapping (ORM)

- The developer defines mapping between Java class and database table

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What is JPA?

- **J**akarta **P**ersistence **A**PI (JPA) … *previously known as Java Persistence API*
  - Standard API for Object-to-Relational-Mapping (ORM)

- Only a specification
  - Defines a set of interfaces
  - Requires an implementation to be usable

www.luv2code.com/jpa-spec

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JPA - Vendor Implementations

www.luv2code.com/jpa-vendors

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What are Benefits of JPA

- By having a standard API, you are not locked to vendor's implementation
- Maintain portable, flexible code by coding to JPA spec (interfaces)
- Can theoretically switch vendor implementations
  - For example, if Vendor ABC stops supporting their product
  - You could switch to Vendor XYZ without vendor lock in

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JPA - Vendor Implementations

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Saving a Java Object with JPA

```
// create Java object
Student theStudent = new Student("Paul", "Doe", "paul@luv2code.com");

// save it to database
entityManager.persist(theStudent);
```

Special JPA helper object

The data will be stored in the database

SQL insert

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Retrieving a Java Object with JPA

```
// create Java object
Student theStudent = new Student("Paul", "Doe", "paul@luv2code.com");

// save it to database
entityManager.persist(theStudent);

// now retrieve from database using the primary key
int theId = 1;
Student myStudent = entityManager.find(Student.class, theId);
```

Query the database for given id

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Querying for Java Objects

```
TypedQuery<Student> theQuery = entityManager.createQuery("from Student", Student.class);

List<Student> students= theQuery.getResultList();
```

Returns a list of Student objects from the database

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JPA/Hibernate CRUD Apps

- Create objects
- Read objects
- Update objects
- Delete objects

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Hibernate / JPA and JDBC

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How does Hibernate / JPA relate to JDBC?

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Hibernate / JPA and JDBC

- Hibernate / JPA uses JDBC for all database communications

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MySQL Database

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MySQL Database

- In this course, we will use the MySQL Database

- MySQL includes two components
  - MySQL Database Server
  - MySQL Workbench

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MySQL Database Server

- The MySQL Database Server is the main engine of the database
- Stores data for the database
- Supports CRUD features on the data

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MySQL Workbench

- MySQL Workbench is a client GUI for interacting with the database
- Create database schemas and tables
- Execute SQL queries to retrieve data
- Perform insert, updates and deletes on data
- Handle administrative functions such as creating users
- Others …

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Install the MySQL software

- Step 1: Install MySQL Database Server
  - **`https://dev.mysql.com/downloads/mysql/`**
- Step 2: Install MySQL Workbench
  - **`https://dev.mysql.com/downloads/workbench/`**

Please install the MySQL software now

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Setup Database Table

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Two Database Scripts

1. Folder: **00-starter-sql-scripts**

   - **01-create-user.sql**
   - **02-student-tracker.sql**

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About: 01-create-user.sql

1. Create a new MySQL user for our application

   - user id: **springstudent**
   - password: **springstudent**

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About: 02-student-tracker.sql

1. Create a new database table: **student**

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Setting Up Spring Boot Project

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Automatic Data Source Configuration

- In Spring Boot, Hibernate is the default implementation of JPA
- **`EntityManager`** is main component for creating queries etc …
- **`EntityManager`** is from Jakarta Persistence API (JPA)

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Automatic Data Source Configuration

- Based on configs, Spring Boot will automatically create the beans:
  - **`DataSource, EntityManager,`** …

- You can then inject these into your app, for example your DAO

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Setting up Project with Spring Initialzr

- At Spring Initializr website, start.spring.io
- Add dependencies
  - MySQL Driver: **`mysql-connector-j`**
  - Spring Data JPA: **`spring-boot-starter-data-jpa`**

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Spring Boot - Auto configuration

- Spring Boot will automatically configure your data source for you

- Based on entries from Maven pom file
  - JDBC Driver: **`mysql-connector-j`**
  - Spring Data (ORM): **`spring-boot-starter-data-jpa`**

- DB connection info from **`application.properties`**

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application.properties

```
spring.datasource.url=jdbc:mysql://localhost:3306/student_tracker
spring.datasource.username=springstudent
spring.datasource.password=springstudent
```

No need to give JDBC driver class name
Spring Boot will automatically detect it based on URL

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Creating Spring Boot - Command Line App

- We will create a Spring Boot - Command Line App
- This will allow us to focus on Hibernate / JPA
- Later in the course, we will apply this to a CRUD REST API

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Creating Spring Boot - Command Line App

```
import org.springframework.boot.CommandLineRunner;
import org.springframework.boot.SpringApplication;
import org.springframework.boot.autoconfigure.SpringBootApplication;
import org.springframework.context.annotation.Bean

@SpringBootApplication
public class CruddemoApplication {

   public static void main(String[] args) {
      SpringApplication.run(CruddemoApplication.class, args);
   }

   @Bean
   public CommandLineRunner commandLineRunner(String[] args) {
      return runner -> {
         System.out.println("Hello world");
      };
   }
}
```

Executed after the Spring Beans have been loaded

Lambda expression

Add our custom code

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JPA Development Process

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JPA Dev Process - To Do List

1. Annotate Java Class

2. Develop Java Code to perform database operations

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Let's just say "JPA"

- As mentioned, Hibernate is the default JPA implementation in Spring Boot

- Going forward in this course, I will simply use the term: **JPA**
  - Instead of saying "JPA Hibernate"

- We know that by default, Hibernate is used behind the scenes

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Terminology

Entity Class

Java class that is mapped to a database table

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Object-to-Relational Mapping (ORM)

Java Class

Database Table

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Entity Class

- At a minimum, the Entity class
  - Must be annotated with @Entity
  - Must have a public or protected no-argument constructor
    - The class can have other constructors

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Constructors in Java - Refresher

- Remember about constructors in Java
- If you don't declare any constructors
  - Java will provide a no-argument constructor for free
- If you declare constructors with arguments
  - then you do NOT get a no-argument constructor for free
  - In this case, you have to explicitly declare a no-argument constructor

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Java Annotations

- Step 1: Map class to database table
- Step 2: Map fields to database columns

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Step 1: Map class to database table

```
@Entity
@Table(name="student")
public class Student {

  ...

}
```

Java Class

Database Table

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Step 2: Map fields to database columns

```
@Entity
@Table(name="student")
public class Student {

    @Id
    @Column(name="id")
    private int id;

    @Column(name="first_name")
    private String firstName;
  ...
}
```

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@Column - Optional

- Actually, the use of @Column is optional
- If not specified, the column name is the same name as Java field
- In general, I don't recommend this approach
  - If you refactor the Java code, then it will not match existing database columns
  - This is a breaking change and you will need to update database column
- Same applies to @Table, database table name is same as the class

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Terminology

Primary Key

Uniquely identifies each row in a table

Must be a unique value

Cannot contain NULL values

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MySQL - Auto Increment

```
CREATE TABLE student (

  id int NOT NULL AUTO_INCREMENT,
  first_name varchar(45) DEFAULT NULL,
  last_name varchar(45) DEFAULT NULL,
  email varchar(45) DEFAULT NULL,
  PRIMARY KEY (id)

)
```


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JPA Identity - Primary Key

```
@Entity
@Table(name="student")
public class Student {

  @Id
  @GeneratedValue(strategy=GenerationType.IDENTITY)
  @Column(name="id")
  private int id;

 ...
}
```


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ID Generation Strategies

Name	Description
GenerationType.AUTO	Pick an appropriate strategy for the particular database
GenerationType.IDENTITY	Assign primary keys using database identity column
GenerationType.SEQUENCE	Assign primary keys using a database sequence
GenerationType.TABLE	Assign primary keys using an underlying database table to ensure uniqueness

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Bonus Bonus

- You can define your own CUSTOM generation strategy :-)
- Create implementation of **`org.hibernate.id.IdentifierGenerator`**
- Override the method: **`public Serializable generate(…)`**

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Save a Java Object

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Sample App Features

- **Create** a new Student
- **Read** a Student
- **Update** a Student
- **Delete** a Student

CRUD

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Student Data Access Object

- Responsible for interfacing with the database
- This is a common design pattern: **Data Access Object (DAO)**

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Student Data Access Object

Methods
save(…)
findById(…)
findAll()
findByLastName(…)
update(…)
delete(…)
deleteAll()

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Student Data Access Object

- Our DAO needs a JPA Entity Manager
- JPA Entity Manager is the main component for saving/retrieving entities

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JPA Entity Manager

- Our JPA Entity Manager needs a Data Source
- The Data Source defines database connection info
- JPA Entity Manager and Data Source are automatically created by Spring Boot
  - Based on the file: application.properties (JDBC URL, user id, password, etc …)
- We can autowire/inject the JPA Entity Manager into our Student DAO

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Student DAO

Step-By-Step

- Step 1: Define DAO interface
- Step 2: Define DAO implementation
  - Inject the entity manager
- Step 3: Update main app

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Step 1: Define DAO interface

```
import com.luv2code.cruddemo.entity.Student;

public interface StudentDAO {

    void save(Student theStudent);

}
```

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Step 2: Define DAO implementation

```
import com.luv2code.cruddemo.entity.Student;
import jakarta.persistence.EntityManager;
import org.springframework.beans.factory.annotation.Autowired;

public class StudentDAOImpl implements StudentDAO {

    private EntityManager entityManager;

    @Autowired
    public StudentDAOImpl(EntityManager theEntityManager) {
        entityManager = theEntityManager;
    }

    @Override
    public void save(Student theStudent) {
        entityManager.persist(theStudent);
    }

}
```

Inject the Entity Manager

Save the Java object

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Spring @Transactional

- Spring provides an **@Transactional** annotation

- **Automagically** begin and end a transaction for your JPA code
  - No need for you to explicitly do this in your code

- This Spring **magic** happens behind the scenes

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Step 2: Define DAO implementation

```
import com.luv2code.cruddemo.entity.Student;
import jakarta.persistence.EntityManager;
import org.springframework.beans.factory.annotation.Autowired;
import org.springframework.transaction.annotation.Transactional;

public class StudentDAOImpl implements StudentDAO {

    private EntityManager entityManager;

    @Autowired
    public StudentDAOImpl(EntityManager theEntityManager) {
        entityManager = theEntityManager;
    }

    @Override
    @Transactional
    public void save(Student theStudent) {
        entityManager.persist(theStudent);
    }

}
```

Handles transaction management

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Specialized Annotation for DAOs

- Spring provides the **@Repository** annotation

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Specialized Annotation for DAOs

- Applied to DAO implementations
- Spring will automatically register the DAO implementation
  - thanks to component-scanning
- Spring also provides translation of any JDBC related exceptions

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Step 2: Define DAO implementation

Specialized annotation for repositories

Supports component scanning

Translates JDBC exceptions

```
import com.luv2code.cruddemo.entity.Student;
import jakarta.persistence.EntityManager;
import org.springframework.beans.factory.annotation.Autowired;
import org.springframework.stereotype.Repository;
import org.springframework.transaction.annotation.Transactional;

@Repository
public class StudentDAOImpl implements StudentDAO {

    private EntityManager entityManager;

    @Autowired
    public StudentDAOImpl(EntityManager theEntityManager) {
        entityManager = theEntityManager;
    }

    @Override
    @Transactional
    public void save(Student theStudent) {
        entityManager.persist(theStudent);
    }

}
```


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Step 3: Update main app

```
@SpringBootApplication
public class CruddemoApplication {

   public static void main(String[] args) {
      SpringApplication.run(CruddemoApplication.class, args);
   }

   @Bean
   public CommandLineRunner commandLineRunner(StudentDAO studentDAO) {
      return runner -> {

         createStudent(studentDAO);
   }

   private void createStudent(StudentDAO studentDAO) {

      // create the student object
      System.out.println("Creating new student object...");
      Student tempStudent = new Student("Paul", "Doe", "paul@luv2code.com");

      // save the student object
      System.out.println("Saving the student...");
      studentDAO.save(tempStudent);

      // display id of the saved student
      System.out.println("Saved student. Generated id: " + tempStudent.getId());
   }

}
```

Inject the StudentDAO

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Retrieving an Object

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JPA CRUD Apps

- Create objects
- Read objects
- Update objects
- Delete objects

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Retrieving a Java Object with JPA

```
// retrieve/read from database using the primary key
// in this example, retrieve Student with primary key: 1

Student myStudent = entityManager.find(Student.class, 1);
```

Entity class

Primary key

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Development Process

Step-By-Step

1. Add new method to DAO interface

2. Add new method to DAO implementation

3. Update main app

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Step 1: Add new method to DAO interface

```
import com.luv2code.cruddemo.entity.Student;

public interface StudentDAO {
    …

    Student findById(Integer id);

}
```


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Step 2: Define DAO implementation

```
import com.luv2code.cruddemo.entity.Student;
import jakarta.persistence.EntityManager;
…

public class StudentDAOImpl implements StudentDAO {

    private EntityManager entityManager;
    …

    @Override
    public Student findById(Integer id) {
        return entityManager.find(Student.class, id);
    }


}
```

No need to add @Transactional since we are doing a query

If not found, returns null

Entity class

Primary key

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Step 3: Update main app

```java
@SpringBootApplication
public class CruddemoApplication {
   …

   @Bean
   public CommandLineRunner commandLineRunner(StudentDAO studentDAO) {
      return runner -> {

         readStudent(studentDAO);
      };
   }

   …
```

```java
private void readStudent(StudentDAO studentDAO) {
   // create a student object
   System.out.println("Creating new student object...");
   Student tempStudent = new Student("Daffy", "Duck", "daffy@luv2code.com");

   // save the student object
   System.out.println("Saving the student...");
   studentDAO.save(tempStudent);

   // display id of the saved student
   System.out.println("Saved student. Generated id: " + tempStudent.getId());

   // retrieve student based on the id: primary key
   System.out.println("\nRetrieving student with id: " + tempStudent.getId());

   Student myStudent = studentDAO.findById(tempStudent.getId());

   System.out.println("Found the student: " + myStudent);
}
```


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Query Objects

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JPA CRUD Apps

- Create objects
- Read objects
- Update objects
- Delete objects

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JPA Query Language (JPQL)

- Query language for retrieving objects

- Similar in concept to SQL
  - where, like, order by, join, in, etc…

- However, JPQL is based on **entity name** and **entity fields**

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Retrieving all Students

Name of JPA Entity … the class name

```
TypedQuery<Student> theQuery = entityManager.createQuery("FROM Student", Student.class);

List<Student> students = theQuery.getResultList();
```

Note: this is NOT the name of the database table

All JPQL syntax is based on entity name and entity fields

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Retrieving Students: `lastName = 'Doe'`

Field of JPA Entity

```
TypedQuery<Student> theQuery = entityManager.createQuery(
                                    "FROM Student WHERE lastName='Doe'", Student.class);

List<Student> students = theQuery.getResultList();
```

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Retrieving Students using OR predicate:

Field of JPA Entity

```
TypedQuery<Student> theQuery = entityManager.createQuery(
                    "FROM Student WHERE lastName='Doe' OR firstName='Daffy'", Student.class);

List<Student> students = theQuery.getResultList();
```

Field of JPA Entity

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Retrieving Students using LIKE predicate:

```
TypedQuery<Student> theQuery = entityManager.createQuery(
                        "FROM Student WHERE email LIKE '%luv2code.com'", Student.class);

List<Student> students = theQuery.getResultList();
```

Match of email addresses that ends with `luv2code.com`

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JPQL - Named Parameters

```
public List<Student> findByLastName(String theLastName) {

    TypedQuery<Student> theQuery = entityManager.createQuery(
                                        "FROM Student WHERE lastName=:theData", Student.class);

    theQuery.setParameter("theData", theLastName);

    return theQuery.getResultList();
}
```

JPQL Named Parameters are prefixed with a colon :

Think of this as a placeholder that is filled in later

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Development Process

Step-By-Step

1. Add new method to DAO interface

2. Add new method to DAO implementation

3. Update main app

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Step 1: Add new method to DAO interface

```
import com.luv2code.cruddemo.entity.Student;
import java.util.List;

public interface StudentDAO {
    ...

    List<Student> findAll();

}
```


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Step 2: Define DAO implementation

```
import com.luv2code.cruddemo.entity.Student;
import jakarta.persistence.EntityManager;
import jakarta.persistence.TypedQuery;
import java.util.List;
…

public class StudentDAOImpl implements StudentDAO {

    private EntityManager entityManager;
    …

    @Override
    public List<Student> findAll() {
        TypedQuery<Student> theQuery = entityManager.createQuery("FROM Student", Student.class);
        return theQuery.getResultList();
    }

}
```

No need to add @Transactional since we are doing a query

Name of JPA Entity

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Step 3: Update main app

```java
@SpringBootApplication
public class CruddemoApplication {

   public static void main(String[] args) {
      SpringApplication.run(CruddemoApplication.class, args);
   }

   @Bean
   public CommandLineRunner commandLineRunner(StudentDAO studentDAO) {
      return runner -> {

         queryForStudents(studentDAO);
      };
   }

   private void queryForStudents(StudentDAO studentDAO) {

      // get list of students
      List<Student> theStudents = studentDAO.findAll();

      // display list of students
      for (Student tempStudent : theStudents) {
         System.out.println(tempStudent);
      }
   }
}
```


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Updating an Object

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JPA CRUD Apps

- Create objects
- Read objects
- Update objects
- Delete objects

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Update a Student

```
Student theStudent = entityManager.find(Student.class, 1);

// change first name to "Scooby"
myStudent.setFirstName("Scooby");

entityManager.merge(theStudent);
```

Update the entity

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Update last name for all students

Field of JPA Entity

```
int numRowsUpdated = entityManager.createQuery(
                        "UPDATE Student SET lastName='Tester'")
                        .executeUpdate();
```

Name of JPA Entity … the class name

Return the number of rows updated

Execute this statement

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Development Process

Step-By-Step

1. Add new method to DAO interface

2. Add new method to DAO implementation

3. Update main app

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Step 1: Add new method to DAO interface

```
import com.luv2code.cruddemo.entity.Student;

public interface StudentDAO {
    …

    void update(Student theStudent);

}
```


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Step 2: Define DAO implementation

```
import com.luv2code.cruddemo.entity.Student;
import jakarta.persistence.EntityManager;
import org.springframework.transaction.annotation.Transactional;
…

public class StudentDAOImpl implements StudentDAO {

    private EntityManager entityManager;
    …

    @Override
    @Transactional
    public void update(Student theStudent) {
        entityManager.merge(theStudent);
    }

}
```

Add @Transactional since we are performing an update

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Step 3: Update main app

```java
@SpringBootApplication
public class CruddemoApplication {
   …

   @Bean
   public CommandLineRunner commandLineRunner(StudentDAO studentDAO) {
      return runner -> {

         updateStudent(studentDAO);
      };
   }

   …
```

```java
private void updateStudent(StudentDAO studentDAO) {

   // retrieve student based on the id: primary key
   int studentId = 1;
   System.out.println("Getting student with id: " + studentId);

   Student myStudent = studentDAO.findById(studentId);

   System.out.println("Updating student...");

   // change first name to "Scooby"
   myStudent.setFirstName("Scooby");
   studentDAO.update(myStudent);

   // display updated student
   System.out.println("Updated student: " + myStudent);
}
```


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Deleting an Object

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JPA CRUD Apps

- Create objects
- Read objects
- Update objects
- Delete objects

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Delete a Student

```
// retrieve the student
int id = 1;
Student theStudent = entityManager.find(Student.class, id);

// delete the student
entityManager.remove(theStudent);
```


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Delete based on a condition

Field of JPA Entity

```
int numRowsDeleted = entityManager.createQuery(
                "DELETE FROM Student WHERE lastName='Smith'")
                .executeUpdate();
```

Name of JPA Entity … the class name

Return the number of rows deleted

Execute this statement

Method name "Update" is a generic term

We are "modifying" the database

Java Class

Student
- id : int - firstName : String - lastName : String - email : String
...

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Delete All Students

```
int numRowsDeleted = entityManager
                        .createQuery("DELETE FROM Student")
                        .executeUpdate();
```

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Development Process

Step-By-Step

1. Add new method to DAO interface

2. Add new method to DAO implementation

3. Update main app

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Step 1: Add new method to DAO interface

```
import com.luv2code.cruddemo.entity.Student;

public interface StudentDAO {
    …

    void delete(Integer id);

}
```


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Step 2: Define DAO implementation

```
import com.luv2code.cruddemo.entity.Student;
import jakarta.persistence.EntityManager;
import org.springframework.transaction.annotation.Transactional;
…

public class StudentDAOImpl implements StudentDAO {

    private EntityManager entityManager;
    …

    @Override
    @Transactional
    public void delete(Integer id) {
        Student theStudent = entityManager.find(Student.class, id);
        entityManager.remove(theStudent);
    }

}
```

Add @Transactional since we are performing a delete

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Step 3: Update main app

```java
@SpringBootApplication
public class CruddemoApplication {
  …

  @Bean
  public CommandLineRunner commandLineRunner(StudentDAO studentDAO) {
    return runner -> {

      deleteStudent(studentDAO);
    };
  }

  …
```

```java
private void deleteStudent(StudentDAO studentDAO) {
  // delete the student
  int studentId = 3;

  System.out.println("Deleting student id: " + studentId);

  studentDAO.delete(studentId);
}
```


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Create Database Tables from Java Code

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Create database tables: `student`

- Previously, we created database tables by running a SQL script

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Create database tables: `student`

- JPA/Hibernate provides an option to automagically create database tables
- Creates tables based on Java code with JPA/Hibernate annotations
- Useful for development and testing

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Configuration

- In Spring Boot configuration file: **`application.properties`**

```
spring.jpa.hibernate.ddl-auto=create
```

- When you run your app, JPA/Hibernate will **drop** tables then **create** them
- Based on the JPA/Hibernate annotations in your Java code

Definition Language

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Creating Tables based on Java Code

Hibernate will generate and execute this

```java
@Entity
@Table(name="student")
public class Student {

  @Id
  @GeneratedValue(strategy=GenerationType.IDENTITY)
  @Column(name="id")
  private int id;

  @Column(name="first_name")
  private String firstName;

  @Column(name="last_name")
  private String lastName;

  @Column(name="email")
  private String email;

  …
  // constructors, getters / setters
}
```

1

2

```java
create table student (id integer not null auto_increment,
                      email varchar(255), first_name varchar(255),
                      last_name varchar(255), primary key (id))
```

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Configuration - application.properties

```
spring.jpa.hibernate.ddl-auto=PROPERTY-VALUE
```

Property Value	Property Description
none	No action will be performed
create-only	Database tables are only created
drop	Database tables are dropped
create	Database tables are dropped followed by database tables creation
create-drop	Database tables are dropped followed by database tables creation. On application shutdown, drop the database tables
validate	Validate the database tables schema
update	Update the database tables schema

When database tables are dropped, all data is lost

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Basic Projects

- For basic projects, can use auto configuration

```
spring.jpa.hibernate.ddl-auto=create
```

- Database tables are **dropped** first and then **created** from scratch

Note:

When database tables are dropped, all data is lost

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Basic Projects

- If you want to create tables once … and then keep data, use: `update`

```
spring.jpa.hibernate.ddl-auto=update
```

- However, will ALTER database schema based on latest code updates
- Be VERY careful here … only use for basic projects

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Warning

```
spring.jpa.hibernate.ddl-auto=create
```

- Don't do this on **Production** databases!!!

- You don't want to **drop** your Production data
  - **All data is deleted!!!**

- Instead for Production, you should have DBAs run SQL scripts

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Use Case

```
spring.jpa.hibernate.ddl-auto=create
```

- Automatic table generation is useful for
  - Database integration testing with in-memory databases
  - Basic, small hobby projects

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Recommendation

- In general, I don't recommend auto generation for enterprise, real-time projects
  - You can VERY easily drop PRODUCTION data if you are not careful ☠

- I recommend SQL scripts ✓
  - Corporate DBAs prefer SQL scripts for governance and code review
  - The SQL scripts can be customized and fine-tuned for complex database designs
  - The SQL scripts can be version-controlled
  - Can also work with schema migration tools such as Liquibase and Flyway

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