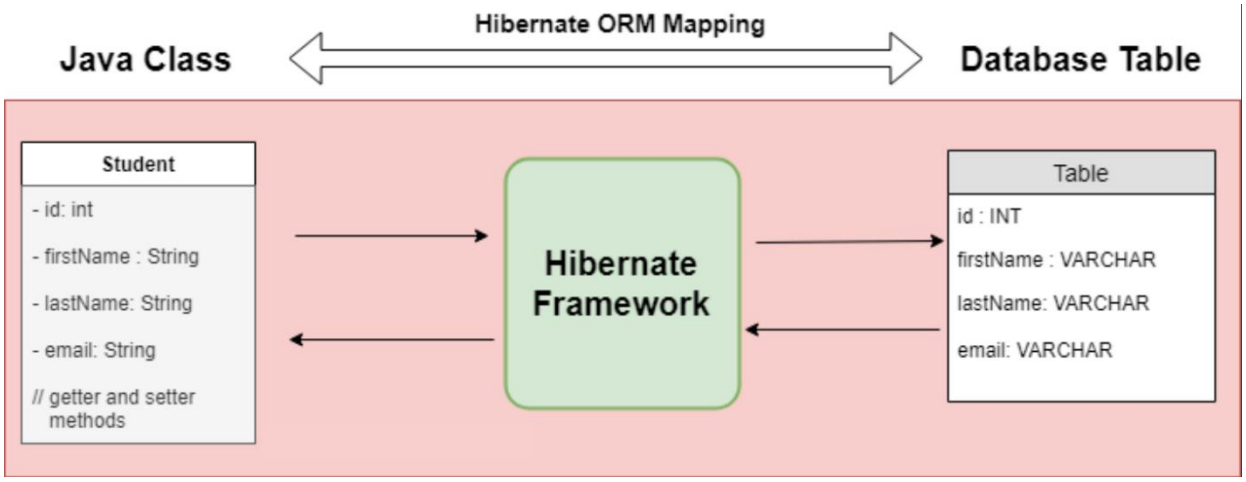
Hibernate ORM Mapping



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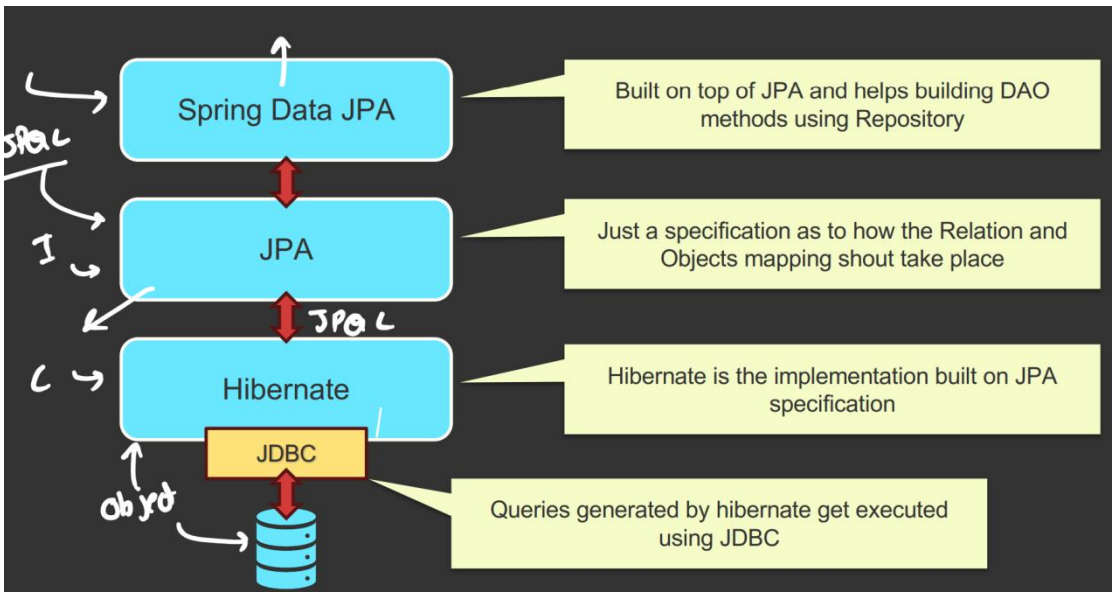


➢ With the help of driver of particular database, we can connect JDBC to it.
  - Inside JDBC, we need to write SQL queries that will be supplied to Database.

➢ Then comes Hibernate, it is responsible for **Object-Relational-Mapping (ORM)**.
  - It'll convert the specific Java object to Database relational entities.
  - Hibernate is the implementation built on JPA specification.

➢ JPA is just a specification as to how the Relation and Objects mapping shout take place.

➢ Then it comes Spring JPA.
  - It is built on top of JPA and helps building DAO (Data Object) methods using Repository.

➢ We can write on top of Spring Data JPA that is high-level data manipulation methods. Or also we can write JPQL on JPA level.

The exact flow from Spring Data JPA to Database

- First Layer is **SPRING DATA JPA**
  - Built by Spring on top of **JPA**.
  - Contains:
    - **JpaRepository interface** (extended by *user-defined repository interfaces*).
    - **SimpleJpaRepository class** (contains *method bodies of JpaRepository*).
  - SimpleJpaRepository already has implementations of CRUD methods (defined inside EntityManager interface of JPA).
  - No method implementation injection at runtime.
  - Spring creates a proxy that forwards repository method calls to **SimpleJpaRepository**.
  - Dependencies like **EntityManager** are **injected** at runtime.
- 2nd Layer is **JPA**
  - Pure Java specification.
  - Defines annotations and interfaces like **EntityManager**.
  - **SimpleJpaRepository** calls methods of **EntityManager**.
  - JPA provides only contracts, no implementations.
- 3rd Layer is **JPA Provider** (**Hibernate** is mainly used)
  - **Hibernate** implements **EntityManager** interface.
  - Provides actual method definitions.
  - Generates SQL queries.
  - Passes SQL to JDBC.
- 4th Layer is **JDBC**
  - Java API for DB communication.
  - Executes SQL generated by Hibernate.
  - Sends SQL to database drivers.
- 5th Layer is **Database Driver**
  - Executes SQL on the database.
  - Performs actual DB operations.

- Hibernate
  - It is a powerful, high-performance Object-Relational-Mapping (ORM) framework that is widely used with Java.
  - It provides a framework for mapping an object-oriented domain model to a relational database.
  - It is one of the implementations of Java Persistence API (JPA) which is a standard specification for ORM in Java.
- JPA
  - It is a specification for ORM in Java.
  - It defines a set of interfaces and annotations for mapping Java objects to database tables and vice versa.
  - It itself is just a guideline, doesn't provide any implementations. Implementation is provided by JPA Provider framework like Hibernate.

Common Hibernate Configurations

- **spring.jpa.hibernate.ddl-auto=update/create/validate/create-drop/none** (1)
  - Update: we want to update the table when we update the entity
  - Create: everytime we running the server, old table will be dropped and create a new.
  - Validate: the table that we have and entity that we have are matching or not
  - Create-drop: create table on running of server and drop that after stopping the server (not used in production)
- **spring.jpa.show-sql=true** (2)
  - If we want to see all the queries being generated underneath
- **spring.jpa.properties.hibernate.format_sql=true** (3)
  - The queries coming from the previous command (2) should be displayed after properly beautifying not in a single line.
- **spring.jpa.properties.hibernate.dialect=org.hibernate.dialect.MySql5Dialect** (optional) (4)
  - Defines the rule that hibernate will use to convert JPQL to queries.
  - Database are having their own dialect.
  - Its optional because it'll pick the proper dialect by itself.

- There are multiple annotations for **Entity** objects

```java
public class Product {

    @Id
    @GeneratedValue(strategy = GenerationType.IDENTITY)
    private Long id;

    // can't be nullable & max length = 23
    @Column(nullable = false, length = 20)
    private String sku;

    @Column(name = "title_x")
    private  String title;

    private BigDecimal price;

    private  Integer quantity;

    @CreationTimestamp
    private LocalDateTime createdAt;

    @UpdateTimestamp
    private LocalDateTime updatedAt;
}
```

  - **@Id**, **@GeneratedValue**, **@Column** (change name, nullable true or false, length if it's a string, etc etc), **@CreationTimeStamp**, **@UpdateTimeStamp** …etc

- **@Table** annotation

```java
@Table(
    name = "employees",
    catalog = "employee_catalog",
    schema = "hr",
    uniqueConstraints = {
        @UniqueConstraint(columnNames = {"email"})
    },
    indexes = {
        @Index(name = "idx_name", columnList = "name"),
        @Index(name = "idx_department", columnList = "department")
    }
)
```

  - There is something called **namespace** in database.
    - **auth.**user, **sales.**user
    - Here both have the same table name "user", but they do not conflict because they belong to different namespaces (auth, sales).

- In MySQL, the database acts as the namespace (mapped using **catalog** in **@Table**).
- In PostgreSQL and Oracle, the schema acts as the namespace (mapped using **schema** in **@Table**).
- So, schema and catalog both represent the same concept (**namespace**), and which one is used depends on the database.

```
UniqueConstraint[] uniqueConstraints() default {};
```

- UniqueConstraint is also an annotation :).
- `public @interface UniqueConstraint {`

```
@Table(
        name = "product_table",
        uniqueConstraints = {
            // column "sku" should be unique
            @UniqueConstraint(name = "sku_unique", columnNames = {"sku"}),
            // columns "title" & "price" combination should be unque
            @UniqueConstraint(name = "title_price_unique", columnNames = {"title_x", "price"})
        },
```

- (**title_x** because we have changed the column name to **title_x**; previous image)
- Name is used to provide a specific name to the constraint. Otherwise it'll generate some random unique name for the constraint.
- **name** is useful during debugging.
- `Duplicate entry 'a@b.com' for key 'UK_3ks8d9'` (without name)
- `Duplicate entry 'a@b.com' for key 'uk_user_email'` (with name)

indexes

- Here the **columnList** is a *String* not a *List*.
- You should give comma separated column names.

```
indexes = {
    @Index(name = "sku_index", columnList = "sku"),
    @Index(name = "title_price_index", columnList = "title, price")
}
```

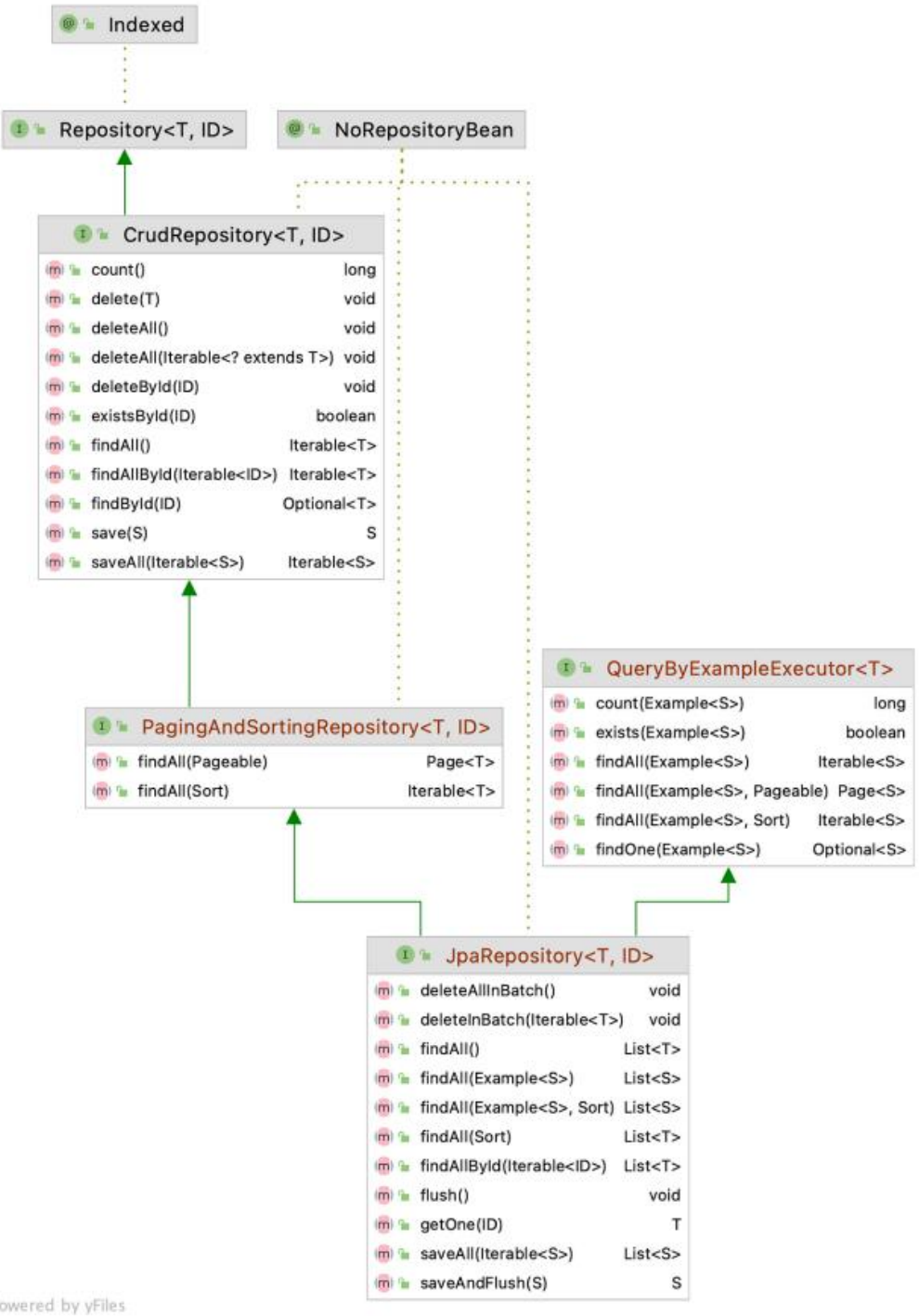
➢ NOTE: **database** should already be present. It'll not create the database inside the server by itself.

➢

- **Indexing** in database.
  - ```
    @Index(name = "idx_user_email", columnList = "email")
    ```
    (JPA)
  - ```
    CREATE INDEX idx_user_email ON users(email);
    ```
    (SQL)
  - An index is a *separate data structure* that stores indexed **column** values along with **row pointers**.
  - It is not a normal table; it is created and managed internally by the database..
    - ```
      a@x.com → row 5
      b@y.com → row 12
      ```
  - But this is not a normal table, it is created and managed by database itself.
  - **Read** queries are ***faster***, but **create**, **update**, **delete** queries are ***slower*** as it needs to update the index table as well.
  -
      ```

Spring Data JPA

- It is a part of the larger Spring Data Family.
- It builds on top of JPA, providing a higher-level and more convenient abstraction for data access.
- Spring data JPA makes it easier to implement JPA-based repositories by providing boilerplate code, custom query methods, and various utilities to reduce the amount of code you need to write.



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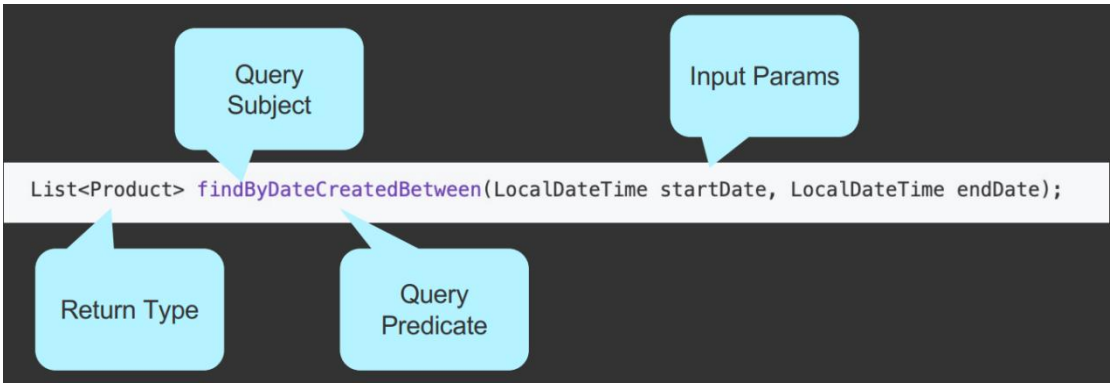
- **SimpleJpaRepository *class*** implements the *JpaRepository interface*. It contains implementation of all the methods of the JpaRepository and its parent interfaces.
- Key Features of Spring Data JPA
  - Repository Abstraction:
    - Provides a *Repository* interface with methods for common data access operations.
  - Custom Query Methods:
    - Allows defining custom query methods by simply declaring method names.
  - Pagination & Sorting:
    - Offers built-in support for pagination and sorting.
  - Query Derivation:
    - Automatically generates queries from method names.
- You'll have to just write the method name in the Repository and no need to implement. It'll be done automatically.
  -
```
@Repository  2 usages
public interface ProductRepository extends JpaRepository<ProductEntity, Long> {

    List<ProductEntity> findByTitle(String title);  1 usage
```
  - Just like this just write the method.
  - NOTE: If you remember the column name is **title_x** not **title**.
    -
```
@Column(name = "title_x")
private  String title;
```
    - **query generation takes place according to the Java object; not Database column**; If you write **findByTitleX** then it'll not work;

- **Rules for Creating Query Methods**
  - 

  - Return type will be mostly **Entity**, **Optional<Entity>** or **List<Entity>**
  - In the diagram, **Query Subject** is **findBy**, and **Query Predicate** is **DateCreatedBetween.**
  - The name of the query method must start with one of the following prefixes
    - find..By, read..By, query..By, get..By
    - Examples: **findByName, readByName, queryByName, getByName**
  - If we want to limit the number of returned query results, we can add the ***First*** or the ***Top*** keyword before the first by word**.**
    - Examples: **findFirstByName**, **readFirst2ByName**, **findTop10ByName**
  - If we want to select unique results, we have to add the Distinct keyword before the first ***By*** word.
    - Examples: **findDistinctByName or findNameDistinctBy** --- both are same
  - Combine property expression with ***And*** and ***Or***
    - Examples: **findByNameOrDescription, findByNameAndDescription**
  - For more, refer to the link: **query keyword reference**
- A few examples:
  - ```
    List<ProductEntity> findByCreatedAtAfter(LocalDateTime after);
    ```
    - To get all the items that were created after a particular time.
  - **findByQuantityGreaterThanAndPriceLessThan(int quantity, int price)**
    - The argument orders should be same as the query.
    ```

- Writing **JPQL** query directly

```
@Query("select e from ProductEntity e where e.title=?1 and e.price=?2")  1 usag
Optional<ProductEntity> findByTitleAndPrice(String title, BigDecimal price);
```

  - **@Query** annotation is used to write the **JPQL** query.
  - **?1 , ?2 , ?3** etc are used to get the argument from the method. In the above image
    - **?1** means **title**
    - **?2** means **price**
  - Instead of **?1 ?2** you can also write **:title** and **:price**

```
@Query("select e from ProductEntity e where e.title=:title and e.price=:price")
Optional<ProductEntity> findByTitleAndPrice(String title, BigDecimal price);
```

  - **NOTE**: JPQL should be written according to Java object (inside Entity), not according to Database table/column name.
    - In database the table name is **product_table** as I have mentioned inside the **@Table** annotation, but the entity name is **ProductEntity**, so we need to pass **ProductEntity** in the JPQL.
    - Also, in the database the column name is **title_x** as I have mentioned **title_x** in the annotation **@Column**, but the field name is **title** in side **ProductEntity** class. So we need to pass **title** in the JPQL query.
    - And also, we are not writing **select *** just like SQL, rather we are writing **select e**. here *select* * will not work.

Sorting & Pagination

- **OrderBy** is used to *Sort*.
  - ```
    List<ProductEntity> findByOrderByPrice();
    ```
  - Instead of **findAll**, here we need to write **findBy**.
  - It'll get all the rows and sort them according to the *price*. **OrderByPrice**.
  - ```
    List<ProductEntity> findByOrderByPriceDesc();
    ```
  - It'll also do the same, but it'll sort in *reverse order*.
  - **Asc** is for ascending, **Desc** is for descending order.
- But it is not proper; because if we want to *sort by some column*, then for each column we need to write one method each. For example *findByOrderByPrice, findByOrderByTitle, findByOrderById* …etc
  - For this we can use **Sort** class.
  - ```
    List<ProductEntity> findBy(Sort sort);
    ```
    - Here we need to get the argument of type **Sort**.
  - ```
    @GetMapping  no usages
    public List<ProductEntity> getAllProducts(@RequestParam(defaultValue = "id") String sortBy) {
        return productRepository.findBy(Sort.by(sortBy));
    }
    ```
    - We can call that method like this. Passing one **Sort** object.
  - Now, the API call should be made confirming according to which column it has to be sorted and its done.
    - `localhost:8080/products?sortBy=price` like this
  - ```
    return productRepository.findBy(Sort.by( ...properties: sortBy, "price"));
    ```
    - If the **sortBy** column is same, then it'll further sort according to "price". like this we can give multiple properties.
  - ```
    return productRepository
            .findBy(Sort.by(Sort.Direction.DESC,  ...properties: sortBy, "price"));
    ```
    - You can give the direction like this as well.
  - ```
    return productRepository
            .findBy(Sort.by(Sort.Order.asc(sortBy), Sort.Order.desc( property: "id")));
    ```
    - If you want different direction i.e. ASC, DESC for different columns then use like this.
    ```

```
Pageable   (interface)  --> input
   |
   v
PageRequest (class)     --> implementation of Pageable

---------------------------------

Page<T>     (interface) --> output
   |
   v
PageImpl<T> (class)     --> implementation of Page
```

- **Pageable** interface represents: **page size, page number, sorting info**
- **PageRequest** is used to create **Pageable** object.
- The query after being run returns **Page** object.
  - Typically we never create object of **Page**.

- **Pageable** is the interface; **PageRequest** is the class which inherit **Pageable** (not direct parent, but ancestor).
  - We need to create one **Pageable** object to do the pagination.
  - **PageRequest** is used to create the object (as of course it is the class; and Pageable type of variable can keep PageRequest type of object; because Pageable is the ancestor of PageRequest)
  - The query methods can return **Page** type of object (if you write return type as List then of course it'll return List instead of Page)

```
int pageNumber = 2;
int pageSize = 10;
Pageable pageable = PageRequest
        .of(pageNumber, pageSize, Sort.by(Sort.Order.desc( property: "price")));

Page<ProductEntity> page = productRepository.findAll(pageable);
return page.getContent();
```

- **findAll** method is already there.
- ```
  Page<T> findAll(Pageable pageable);
  ```
- It returns an object of type **Page**.
- **getContent()** method is used to extract the **List of Entity** from the **Page**.
  ```

- **NOTE** ----------

- The return type of the query doesn't only depends upon **Pageable** parameter. It depends on the return type of the method.
  - ```
    List<ProductEntity> findBySkuContaining(String sku, Pageable page);
    ```
  - I wrote this method, and the return type is **List<ProductEntity>** so here **List** will be returned.
  - ```
    int pageNumber = 2;
    int pageSize = 10;
    Pageable pageable = PageRequest
            .of(pageNumber, pageSize);
    return productRepository.findBySkuContaining( sku: "SKU", pageable);
    ```
  - But if I write **Page<ProductEntity>** in that query then it'd have return Page type of object.
  - ```
    Page<ProductEntity> findBySkuContaining(String sku, Pageable page);
    ```
  - ```
    return productRepository.findBySkuContaining( sku: "SKU", pageable).getContent();
    ```
    - Now I need to use **getContent()** method to get the List out of the Page object.
- By default, no query method supports **sorting** or **pagination**. You need to pass **Sort** type of parameter to sort and **Pageable** type of parameter to make pagination.
- ----------
- If you return **Page<ProductEntity>** instead of **List<ProductEntity>** then you'll get some **metadata** along with the **contents**.
-
  ```
  {
    "content": [ … ], // 10 items
    "empty": false,
    "first": false,
    "last": false,
    "number": 2,
    "numberOfElements": 10,
    "pageable": { … }, // 6 items
    "size": 10,
    "sort": {
        "empty": true,
        "sorted": false,
        "unsorted": true
    },
    "totalElements": 60,
    "totalPages": 6
  }
  ```

  (like this)

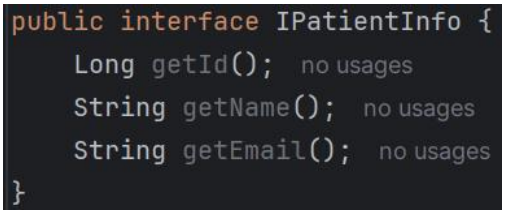
Projection in Spring Data JPA

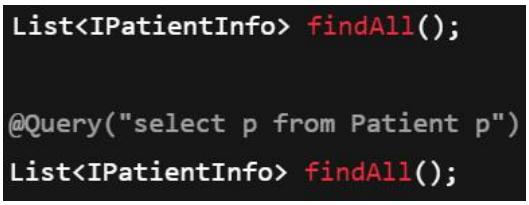
- A projection is a mechanism that allows you to define what data should be exposed to the **caller**, independent of how much data is fetched from the database.
- Returning full data can still be a projection if you are controlling what the caller can access.
- **Method-1 (DTO Interface)**
  - We are giving DTO directly to the repository; but as DTO interface is a view only model; so it doesn't hamper the design pattern.
  - ```
    public interface IPatientInfo {
        Long getId();  no usages
        String getName();  no usages
        String getEmail();  no usages
    }
    ```
  - But there is no **variables** here so modification is not possible.
  - ```
    @Query("select p.id as id, p.name as name, p.email as email from Patient p")
    List<IPatientInfo> getAllPatientsInfo();
    ```
  - ```
    List<IPatientInfo> patientList = patientRepository.getAllPatientsInfo();

    for(IPatientInfo p: patientList) System.out.println(p);
    ```
  - ```
    {id=1, name=Aarav Sharma, email=aarav.sharma@example.com}
    {name=Diya Patel, id=2, email=diya.patel@example.com}
    {id=3, name=Dishant Verma, email=dishant.verma@example.com}
    {name=Neha Iyer, email=neha.iyer@example.com, id=4}
    {name=Kabir Singh, email=kabir.singh@example.com, id=5}
    ```
  - It'll work.
  - In the above query i.e. **"select p.id as id, p.name as name, p.email as email from Patient p"** the aliases are important i.e. **id**, **name**, **email**,
    - **id** will be mapped to **getId**
    - **name** will be mapped to **getName** ..etc

- **NOTE**
  - In case of **interface DTO**, it doesn't have any field. So **Spring Data** will not be able to create an object of this interface and return.
    - So, it creates one proxy class that implements the DTO interface.
    - Now DTO's getter methods will be forwarded to Entity's getter methods with the help of that Proxy.
    - Means the data you are getting is from the Entity itself.
    - ```
      @Query("select p from Patient p")  1 usage
      List<IPatientInfo> getAllPatientsInfo();
      ```
    - ```
      List<IPatientInfo> patientList = patientRepository.getAllPatientsInfo();

      for(IPatientInfo p: patientList) System.out.println(p);
      ```
    - When you execute this, You will see **entity-like output** because **toString()** is delegated to the entity. And it is basically **entity.toString()** .
      - For each object, **toString()** call was delegated to **toString()** of **entity**
    - Printed output ≠ actual object type
    - Actual object = proxy
    - ```
      Patient(id=1, name=Aarav Sharma, birthDate=1990-05-10, email=aarav.sharma@example.com, gender=MALE, bloodGroup=O_POSITIVE, createdAt=null)
      ```
  - In case of **class DTO** (lets assume only getters are there; no setters).
    - In this case, Spring/Hibernate doesn't need to create one proxy class because it can directly create one object of type **DTO class** because it's not an interface.
    - So, in case of **class DTO** (even if setters are not there), the object of type DTO class will be returned; No proxy class is required here.
      ```

- This is my **DTO Interface** (for reference of next explanations)
  - 

- 2 Types of projections are there:
  - **Entity-backed Projection**
  - **Tuple-backed Projection**
- **Entity-Backed Projection**
  - 

  - Both are same, if you don't give the query then it'll by default write that query only (which is being mentioned in the image)
  - So, here it is fetching the full **entity objects** which is of type **Entity**.
  - Flow will be like:
    - **Hibernate** fetches **Patient Entity** object from the database (As full **entity** has to be fetched according to the query)
    - **Spring** creates a **proxy** that implements the **DTO Interface** (IPatientInfo in our case)
    - **Proxy** holds a reference to the **InvocationHandler**.
    - The **InvocationHandler** holds a reference of the **Entity**.
    - Now, whenever the method will be called from the DTO will be delegated to Entity. Proxy is responsible for this.
      - **dto.getName()** ---- Proxy --- handler ----- **entity.getName()**
  - Here no data is copied;
  - No aliases are needed;
  - The data directly comes from the **entity**.
  - If you are wondering how it is able to know about the **Entity**, then you can remember we were passing **Entity** and **Id type** in the generics of **JpaRepository**.

- **Tuple-Backed Projection**
  -
```
@Query("""
select p.id as id, p.name as name, p.email as email
from Patient p
""")
List<IPatientInfo> findAll();
```
  - Here you need to give the query; and instead of fetching the whole **entity**, only select some specific columns that is being mentioned in the **DTO interface**.
  - In this case **aliases** are needed.
  - As here only some specific columns are being fetched from the table, so there is no need of keeping reference of **Entity**.
  - Flow:
    - **Hibernate** does not create entities.
    - Query returns selected column values.
    - **Spring** keeps the **tuple/map** inside the **InvocationHandler**.
    - **Spring** creates a **proxy** that implements **DTO Interface** (IPatientInfo in our case)
    - **Proxy** holds a reference of **InvocationHandler** (just like previous case)
    - Previously **InvocationHandler** was holding a reference of **Entity,** but in this case it is holding a reference of **Map/tuple**.
    - When **getter** is called, **proxy** delegates that method call to **InvocationHandler**, which reads from **tuple/map** and returns the result.
    -
```
Proxy (implements DTO interface)
   |
   v
InvocationHandler
   |
   v
Tuple / Map (query result)
```

Some experiments:

- **Experiment-1**
  - Interface DTO (id, name, email) (IPatientInfo)

```
public interface IPatientInfo {
    Long getId();  no usages
    String getName();  no usages
    String getEmail();  no usages
}
```

  - PatientRepository (fetching the whole **entities**)

```
@Query("select p from Patient p")  2 usage
List<IPatientInfo> getAllPatientsInfo();
```

  - PatientController (returning the IPatientInfo type object)

```
@GetMapping  no usages
public List<IPatientInfo> getData() {
    List<IPatientInfo> patientList = patientRepository.getAllPatientsInfo();
    return  patientList;
}
```

  - The response will be proper

```
[
    {
        "name": "Aarav Sharma",
        "id": 1,
        "email": "aarav.sharma@example.com"
    },
    {
        "name": "Diya Patel",
        "id": 2,
        "email": "diya.patel@example.com"
    },
    {
```

  - Reason:
    - **IPatientInfo** (Interface DTO) is having the getters for **name, id, email** which is delegated to **Patient** (Entity).
    - From the **entity objects** the **getter** methods are being called and the result is properly being generated.
- **Experiment-2**
  - Interface DTO (name, email) (IPatientInfo)

```
public interface IPatientInfo {
    String getName();  no usages
    String getEmail();  no usages
}
```

- PatientRepository (fetching the **id** of the entities)

```
@Query("select p.id as id from Patient p")
List<IPatientInfo> getAllPatientsInfo();
```

  - **alias** is being used for **id** (here **getId()** will be called; otherwise it'd be null without alias)

- PatientController (returning the IPatientInfo type object)

```
@GetMapping  no usages
public List<IPatientInfo> getData() {
    List<IPatientInfo> patientList = patientRepository.getAllPatientsInfo();
    return  patientList;
}
```

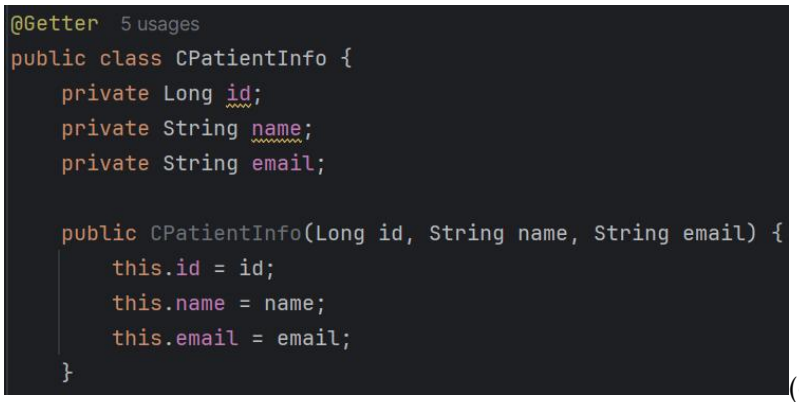
- Now **name** and **email** will be **null**

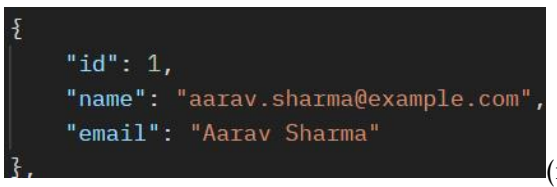
```
[
    {
        "name": null,
        "email": null
    },
    {
        "name": null,
        "email": null
```

- Reason:
  - IPatientInfo (Interface DTO) is having the getters for name, email.
  - But now **getName()** and **getEmail()** are not there because now we don't have **entity** objects; rather we have **map/tuple** which are containing only **id**. So, here only **getId()** will work.
  - But **IPatientInfo** contains **email, name** so it is null now.

➢ Interface DTOs are not flexible;

- Only one type of response can be sent.
- The object cannot be edited as it was coming from the Map(in case of few columns) or Entity(in case of whole entity). So, Interface DTO are only view-only.
- So, class based DTO are used which can be modified, multiple types of responses are supported.

- **Class DTO**
  - If the DTO class is containing only one constructor, then the JPQL query can be written normally like Interface DTO.
    - 
```
@Getter  5 usages
public class CPatientInfo {
    private Long id;
    private String name;
    private String email;

    public CPatientInfo(Long id, String name, String email) {
        this.id = id;
        this.name = name;
        this.email = email;
    }
```
(class DTO)
  - ```
@Query("select p.id as id, p.name as name, p.email as email from Patient p")
List<CPatientInfo> getAllPatientsInfoConcrete();
```
    - For this query, the response will be like the below:
    - 
```
[
    {
        "id": 1,
        "name": "Aarav Sharma",
        "email": "aarav.sharma@example.com"
    },
    {
        "id": 2,
        "name": "Diya Patel",
        "email": "diya.patel@example.com"
```
(all fields are coming)
  - ```
@Query("select p.id as id, p.name as name from Patient p")
List<CPatientInfo> getAllPatientsInfoConcrete();
```
    - It'll give "Internal Server Error" because the constructor is accepting 3 arguments but we are giving only one.
  - **NOTE:** In the JPQL query, the fields should be in same order as defined in the constructor; otherwise wrong fields will be passed in the constructor.
    - ```
@Query("select p.id as id, p.email as email, p.name as name from Patient p")
List<CPatientInfo> getAllPatientsInfoConcrete();
```
    - 
```
{
    "id": 1,
    "name": "aarav.sharma@example.com",
    "email": "Aarav Sharma"
},
```
(it'll give wrong response like this)
```

- If the type of fields are different then it'll give error instead of giving response.

- So, till now we were having only single constructor, but in case of multiple constructor we need to pass the **DTO class reference** in the JPQL query instead of writing like this normally.

```
public CPatientInfo(Long id, String name, String email) {
    this.id = id;
    this.name = name;
    this.email = email;
}

public CPatientInfo(Long id, String name) {  no usages
    this.id = id;
    this.name = name;
}
```

  - So now I have 2 constructors.

```
@Query("select " +  1 usage   Anuj Kumar Sharma
        "new com.codingshuttle.springboot0To100.hospitalManagementSystem.dto.CPatientInfo(p.id, p.name, p.email)" +
        " from Patient p")
List<CPatientInfo> getAllPatientsInfoConcrete();
```

  - Like this you need to write.
  - **new** keyword is must to create object.
  - No aliases are required here.
  - 
(response)

```
@Query("select " +  1 usage   Anuj Kumar Sharma
        "new com.codingshuttle.springboot0To100.hospitalManagementSystem.dto.CPatientInfo(p.id, p.name)" +
        " from Patient p")
List<CPatientInfo> getAllPatientsInfoConcrete();
```

  - Here I passed just 2 fields (**id** and **name** as per the 2nd constructor).
  - 
  - Now if you see, all the fields are coming but having **null** values.
  - To avoid that **@JsonInclude(JsonInclude.Include.NON_NULL)** is used.

```
@Getter  5 usages
@JsonInclude(JsonInclude.Include.NON_NULL)
public class CPatientInfo {
```

- Now I added this here.

```
[
    {
        "id": 1,
        "name": "Aarav Sharma"
    },
```

- Now if you see, only the non-null fields are being displayed.

➢ Aggregate JPQL queries

- **NOTE:** Aggregate functions can have **aliases** but those aliases should not be used for **order by** and **group by**.

```
select p.bloodGroup as bloodGroup, count(p) as countPeople
from Patient p
group by p.bloodGroup
order by count(p) desc
```

- You can see here, I have given alias for **count(p)** which is **countPeople** but that alias name is not given on the side of **order by**.
- I have mentioned **count(p)** on the side of **order by**.
- Also, you cannot give * just like SQL query. Here you need to give the object name (**p**)
- Instead of field name, **p.fieldName** should be given in **camelCase** (in db it'll be in **snake_case**)
- This is only valid for JPQL queries.

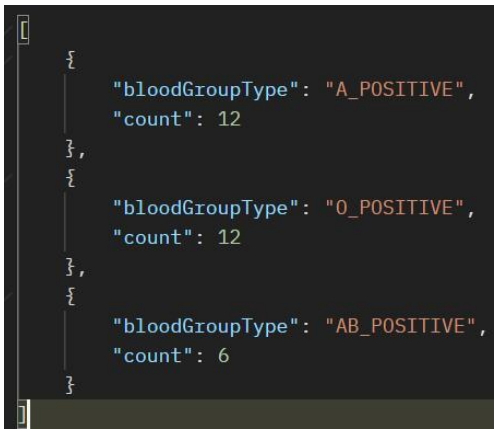
```
@Getter  5 usages
public class CPatientInfoAgg {
    private final BloodGroupType bloodGroupType;
    private final Long count;

    public CPatientInfoAgg(BloodGroupType bloodGroupType, Long count) {
        this.bloodGroupType = bloodGroupType;
        this.count = count;
    }
}
```

- This is my **DTO class** for that aggregation query.

```
@Query("select p.bloodGroup as bloodGroup, count(p) " +  1 usa
        "from Patient p " +
        "group by p.bloodGroup " +
        "order by count(p) desc")
List<CPatientInfoAgg> getAllPatientsInfoConcreteAggregate();
```

- It'll give the proper response.



```
[
    {
        "bloodGroupType": "A_POSITIVE",
        "count": 12
    },
    {
        "bloodGroupType": "O_POSITIVE",
        "count": 12
    },
    {
        "bloodGroupType": "AB_POSITIVE",
        "count": 6
    }
]
```

```
@Query("select " +  1 usage  new *
        "new com.codingshuttle.springboot0To100.hospitalManagementSystem.dto.CPatientInfoAgg(p.bloodGroup, count(p))"
        "from Patient p " +
        "group by p.bloodGroup " +
        "order by count(p) desc")
List<CPatientInfoAgg> getAllPatientsInfoConcreteAggregate();
```

- It is preferable to use **class reference** to write the JPQL queries.

➢ **@Params** is used to bind a *parameter name* to a *particular JPQL value.*

```
@Transactional  no usages  new *
@Modifying
@Query("update Patient p set p.name = :name where p.id = :id")
int updatePatientNameWithId(@Param("name") String patientName, @Param("id") Long patientId);
```

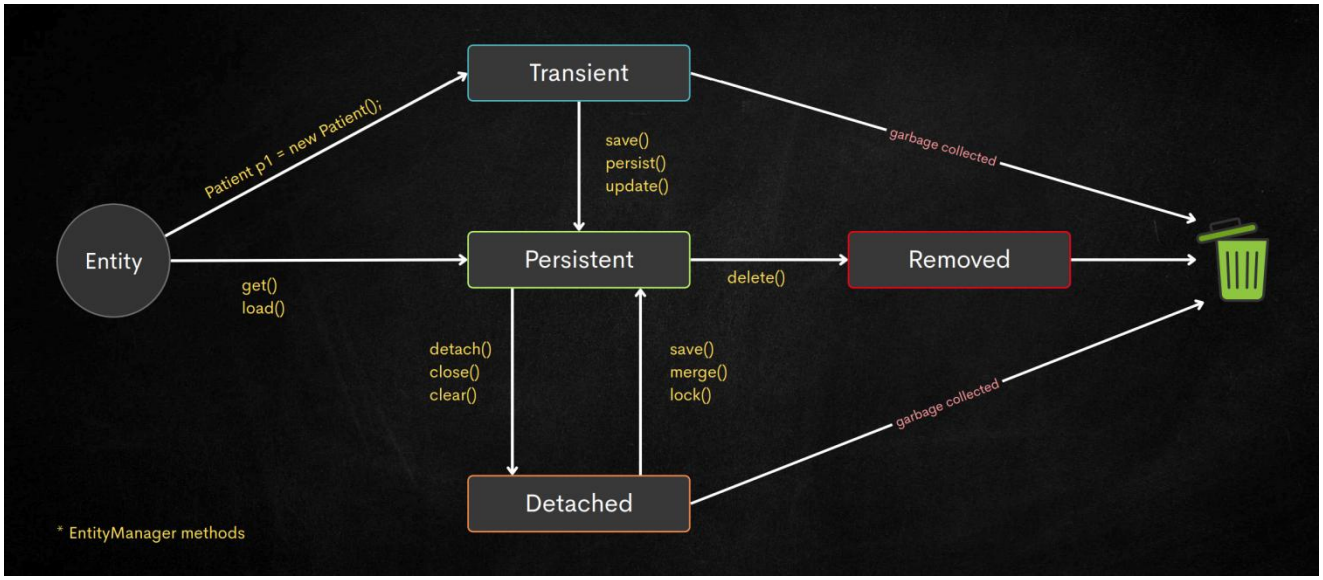
- Here I am executing one **update** query.
- You can see the parameter names are **patientName** and **patientId** but I have bound those with **name** and **id** respectively using **@Params** annotation.
- And also I am using **:name** and **:id** in the JPQL query.

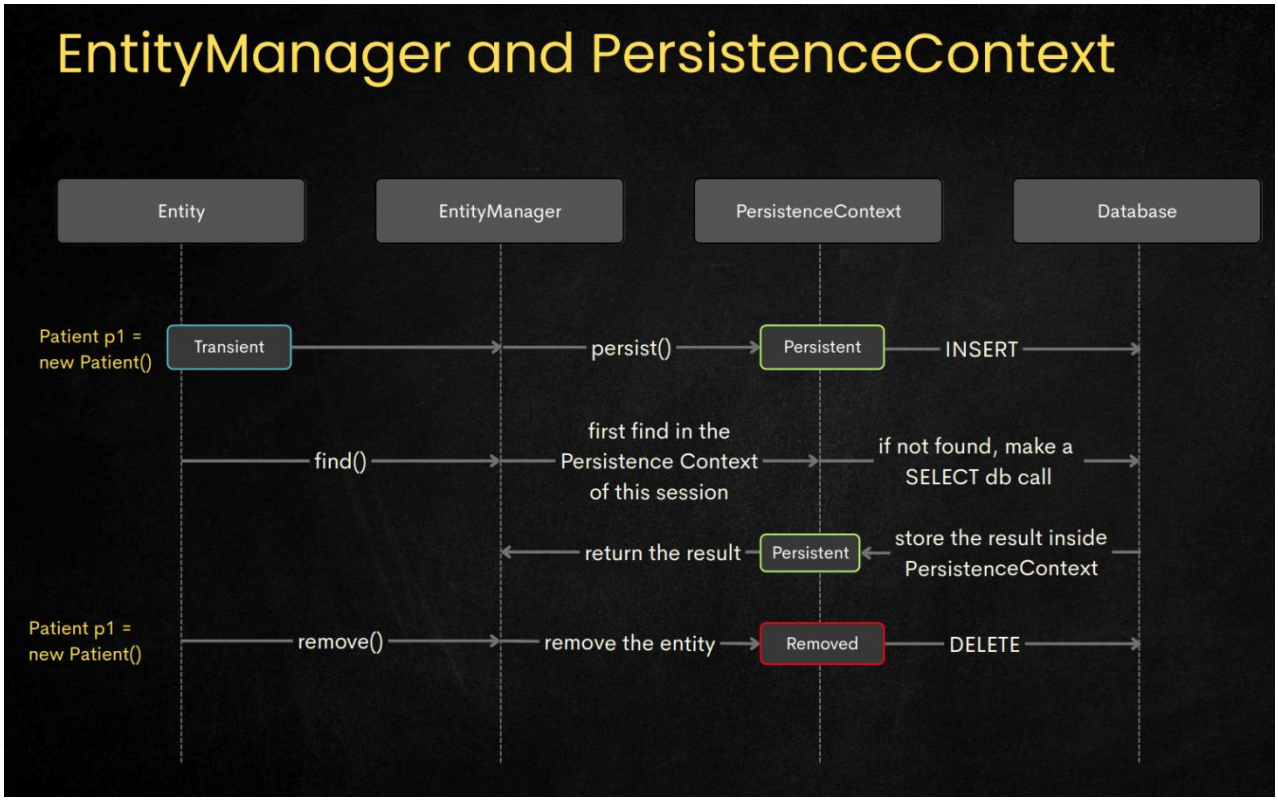
➢ **@Modifying** is required in case of **modification** of database.

- By default **Spring** thinks that the query is of **select** type. So, it expects some **data to be returned** from the database.
- Hence, it'll read those data and give response.
- But, in case of **create/update/delete** method, no data is returned; only one number of *rows affected* will be returned.
- So, **@Modifying** will tell spring that don't expect any data to be returned.

- **@Modifying** will always go with **@Transactional** because you are changing the database state. And it means its involving one **transaction**.

Hibernate Entity Lifecycle, Entity Manager, Persistence Context





- **PatientEntity p = new PatientEntity()**
  - This will take the state to **Transient**.
  - This is only used for **creating new entry**.
  - So, basically only **create** is related to **transient state**, other operation **(update, delete, read)** doesn't include **transient state** at all.
  - In **transient state**, it is only a pure Java object; nothing more.
  - **Transient state is not managed by EntityManager; because it is pure Java object.**

- Either you create one object just like above and call **repository.save(p)** or you are making the **get** call like **repository.findById(**id**)** to get the **entity**, it'll be remaining in the **Persistence Context** only.
  - **Persistence Context** is nothing but a **run-time** state that holds all the **changes** being made, or **data** being fetched till now to **reduce the number of database calls**.
  - For read, it'll check in the **Persistence Context** , if the entry is present then it'll directly return; otherwise **query the db, fetch the data, store the data in Persistence Context, return the data**.
  - Once all the **requests are being processed** (it may be update, or delete, or create; because **read happens directly only**), when the **transaction is coming to the end**, it **commits all the changes to the database at once**. Hence reducing the number of **db calls**.
  - **persist()** puts an object into the Persistence Context **WITHOUT reading** from DB
  - **find()** puts an object into the Persistence Context **BY reading** from DB (**if needed**)
- Simple thing: if the operation is of type **create, update, delete**, then it'll keep all the operations within it; and when the **transaction ends** it trigger those queries to **db**.
- If the **entity** is made **Detached** and left hanging there in the **Transactional method;** and after that method ends if the **reference of the entity** is destroyed; then the **entity will be garbage collected**.
- Same for **remove** and **transient(create)** as well;
- Means its normal Java concept; if the **variables** that were holding the reference of the **entity object** are destroyed; then the **entity object** will be garbage collected; it has nothing to do with the **transient** or **persistence** or **detach** state.
- **IMPORTANT: @Transactional** is required to make proper use of **Persistence Context**. If **@Transactional** is not mentioned, then there is no guarantee that each method will run in same **Persistence contexts**.
- **Some Points to Remember**
  - Repository object will be having EntityManager's methods.
  - **JpaRepository** will be implemented by **SimpleJpaRepository** class.
  - **SimpleJpaRepository** class will *call the methods* of **EntityManager**.
    - (Hibernate implements the EntityManager interface)
  - So, we call the methods like
    - **repository.save(entityObject)**
    - So, under the hood it is called like
    - **entityManagerObject.persist(entityObject)**

- **persist** for *create*, **merge** for *update*, **delete** for *remove*.

```
public <S extends T> S save(S entity) {
    Assert.notNull(entity, message: "Entity must not be null");
    if (this.entityInformation.isNew(entity)) {
        this.entityManager.persist(entity);
        return entity;
    } else {
        return (S) this.entityManager.merge(entity);
    }
}
```

  - It's the SimpleJpaRepository class's save method.
  - If it is **isNew** then **persist** else **merge** for update.

Garbage Collection

- Garbage Collection is **purely a Java concept**
- **objects are created inside heap**
- As variables are **created on stack** so after the execution of their respective scope, those variables will be destroyed.
- So, when all the **variables holding reference to an object** are **destroyed** or **cleared**, and there is **no variable present which is containing the reference of that object** so that **JVM can reach that object**, then **the object will be eligible for garbage collection**.
- JVM can not reach the object means: JVM is not able to find any variable(normal or static or anything) that contains the reference of the Object. So, the **reference of the object** is lost now. So In that case JVM send the Object for garbage collection.

Relationship Owning side and Inverse Side

- **In every bidirectional JPA relationship, exactly ONE side must be the owner.That owner is the side that contains the foreign key in the database.**
- **How to know which is OWNING and which is INVERSE?**
  - Just find out where should the **foreign key** can be stored?
  - Normally the decision making will be like:
    - For 2 entities **entity-1** and **entity-2**
    - If **entity-1** can exist without **entity-2** then **entity-2** should contain the **foreign key** (i.e. **primary** key of **entity-1**); so **entity-1** is **inverse** and **entity-2** is **owning**.
      - One catch will be here; lets say 2 entities are there **user** and **profile**.
      - **user** can exist without **profile** but vice-versa is not true.
      - So, **profile** should contain the FK.
      - But, its upon USER's decision that he'll create his profile or not so in this case PROFILE can be **null** as well.
      - So, in this case it is better to keep FK in **user** table instead of **profile**.
- **One-To-One** mapping in JPA
  - Lets say **USER** and **PASSPORT**.
  - PASSPORT is the *owning* and USER is the *inverse*.
  - **inverse** side will contain **mappedBy** in JPA.
  - **@OneToOne**
    - It'll tell Hibernate that I need one **foreign key** column in my table.
    - If you pass **mappedBy** then it'll think that "okay, my other half has already kept me; I don't need to keep that"
    - without **mappedBy** hibernate thinks this is the owner. If you don't write **mappedBy** in neither of 2 entities (User and Passport) then it'll create foreign key column in both.
    - **mappedBy** will contain the **variable name** **(of object; not database column)** which is created in the **owning side** as the value.

```
@Entity  1 usage  new *
class Passport {
    @Id  no usages
    private Long id;

    @OneToOne  no usages
    @JoinColumn(name = "user_id")
    private User user;
}
```

- Here owning type has variable name: **user**

```
@Entity  1 usage  new *
class User {

    @Id  no usages
    private Long id;

    @OneToOne(mappedBy = "user")
    private Passport passport;
}
```

- So, **user** has to be given as the value of **mappedBy** in inverse.

- **@JoinColumn**
  - it is just used to provide name of foreign key column; if you don't give this annotation then by default the column name will be like the below:
    - Let inverse table is **Person** and **id** field is **myPmId**
    - The column name would be: **person_my_pm_id**. (if @Column doesn't contain any different column name; else that column name will be created)
  - **@JoinColumn("person_id")** it means nothing but "store the primary key of inverse table in my table as foreign key under the column having name **person_id**"
  - Means the **foreign key** column will be named as **person_id.**
  - In case of **person_id** I can even right **@JoinColumn("lalala_lululu")**

➢ **One-to-Many** or **Many-to-One** mapping in JPA

- **Many side will always be the owning type; hence foreign key will be there in the Many side only**.
- **Many side:**
  - **@ManyToOne**
  - **@JoinColumn** (if you want a personalize column name)
- **One side:**
  - **@OneToMany(mappedBy)**

➢ **Many-to-Many** mapping in JPA

- This is slightly different than the previous mappings.
- Here **No FK in either of tables.**
- **Relationship will be stored in *another* table.**
- **Any table can be *owning* and other will be *inverse*** (its completely up-to **you**)

```
Student
-------
id (PK)

Course
------
id (PK)

student_course   ← join table
---------------
student_id (FK → Student.id)
course_id  (FK → Course.id)
```

- (Student, Course)
- I chose **Student** as the ***owning*** type.

```
@Entity
class Student {

    @Id
    private Long id;

    @ManyToMany
    @JoinTable(
        name = "student_course",
        joinColumns = @JoinColumn(name = "student_id"),
        inverseJoinColumns = @JoinColumn(name = "course_id")
    )
    private Set<Course> courses;
}
```

- **(owning)**
  - Here **@JoinTable** is used; inside which **@JoinColumn** is used.
    - Again, here also **@JoinColumn** is not mandatory.

```
@Entity
class Course {

    @Id
    private Long id;

    @ManyToMany(mappedBy = "courses")
    private Set<Student> students;
}
```

- **(inverse)**

```
course.getStudents().add(student); // ❌ ignored
student.getCourses().add(course);  // ✅ persisted
```

`Student` → owning side
`Course` → inverse side

Cascading

- It tells persistence provider (Hibernate) what operations to propagate from a **Parent entity to Child entity**.
- NOTE: **owning** and **inverse** are no way related to **parent entity** and **child entity** concept.
- The **orphanRemoval** and **cascade** are written in **Entity** level. If you call the method like **deleteById** it is *not guaranteed* that those **cascade** will be used.
  - You need to call the method **delete()** which take an **entity object** as the argument.
- **cascade vs orphanRemoval**
  - **cascade** means if some operation is being executed on **parent** entity (**create, update, delete**) then the same operation will be executed on **child** entities.
  - **orphanRemoval** means if the **reference is gone**, then delete the object that was being referenced (just like GC in Java)

```
// It is inside Insurance Entity
@OneToOne(mappedBy = "insurance", orphanRemoval = true)
Patient patient;
```

    - If I set **patient=null** for the **insurance entity object**, and if there is no **entity that has reference of that particular patient entity object**, then that entity will be deleted.
    - In simple terms, when an **entity becomes orphan** (no parents are there), then it'll be deleted.
    - Its independent of **owning/inverse** concept.
  - Simple analogy:
    - **cascade :** if I am being punished, all my children will also be punished.
    - **orphanRemoval :** I don't want my children now; if no one has made them their children then remove them.

➢ **NOTE**

- In case of **cascade** or **orphanRemoval**, even the **repository method** will not be able to manage the **transaction** properly.
- So, its better to use **@Transactional** in the method when doing **CUD** (create, update, delete) operations.
- If the parent function contains **@Transactional**, and the child function (being called in the parent function) is also having **@Transactional**, then also it won't give error. It is good practice to use @Transactional

```
@Service
public class PatientService {

    @Transactional
    public void outerMethod() {
        appointmentService.deleteAppointments();
    }
}

@Service
public class AppointmentService {

    @Transactional
    public void deleteAppointments() {
        // joins same transaction
    }
}
```

- Its safe.

➢

```java
@Transactional  1 usage
public Insurance assignInsuranceToPatient(Insurance insurance, Long patientId) {
    // patient to insurance: one-to-one
    // insurance: owning, patient: inverse
    Patient patient = patientRepository.findById(patientId).orElseThrow();
    patient.setInsurance(insurance);

    // optional: if you want to use insurance object in this scope
    insurance.setPatient(patient);

    return insurance;
}
```

- Here this service method is assigning one **insurance** to the **patient**.
- **@Transactional** is required to make these whole queries run in a single **persistence context**.
- If you remember, without **@Transactional**, all the method may not run in same **persistence context**.

```java
@Test
public void testAssignInsuranceToPatient() {
    Insurance insurance = Insurance.builder()
            .provider("HDFC Ergo0")
            .policyNumber("HDFC_2369")
            .validUntil(LocalDate.of( year: 2025, month: 3, dayOfMonth: 10))
            .build();
    var updatedInsurance = insuranceService.assignInsuranceToPatient(insurance,  patientId: 1L);
    System.out.println(updatedInsurance);
}
```

- It is the test method; but it'll fail because we have not made the **patient entity** as **cascade** yet. So, even if the **patient** is created, it'll not create the **insurance**.

```java
@OneToOne(
        cascade = CascadeType.ALL
)
@JoinColumn(name = "insurance_id")
Insurance insurance;
```

- NOW IT WILL PASS
- (or)

```java
@OneToOne(
        cascade = { CascadeType.PERSIST, CascadeType.MERGE }
)
@JoinColumn(name = "insurance_id")
Insurance insurance;
```

- There are 2 sides: **owning** & **inverse**.
  - As we know **owning** side will contain the foreign key.
  - So, if you try to delete the **inverse** entity then it'll not happen; because it is being referenced in another table (**owning** table)
  - **You cannot delete the inverse side of a relationship while the owning side still points to it.**
- Some points to be remembered:
  - **orphanRemoval** on *inverse* side is of no use;
    - Because, **inverse** side doesn't have a solid *foreign key* column;
    - If just keep one reference of the **owning** entity to fetch the data and store there;
  - **cascade** doesn't care about **owning/inverse**. It'll execute all the operation, that is being executed to the **parent entity,** to **every child entities whose references are there in current entity**.
  -
- **orphanRemoval** example
  -
```
@Transactional  no usages  new *
public Insurance updateInsuranceToPatient(Insurance insurance, Long patientId) {
    Patient patient = patientRepository.findById(patientId).orElseThrow();
    patient.setInsurance(insurance);

    return insurance;
}
```
    - Here I am **updating** the insurance.
    - So, **previous insurance object became orphan**, hence it'll be deleted.
    - **new insurance object will be created, saved; then it'll be added to patient.**
  -
```
@Transactional  no usages  new *
public Insurance removeInsuranceToPatient(Insurance insurance, Long patientId) {
    Patient patient = patientRepository.findById(patientId).orElseThrow();
    patient.setInsurance(null);

    return insurance;
}
```
    - Same here as well; in stead of changing the insurance, here insurance is being removed;
-

Key Points About orphanRemoval

- When It Triggers:
  - For @OneToMany: When an entity is removed from the collection (e.g., List.remove(), clear(), or reassigning a new collection).
  - For @OneToOne: When the reference is set to null or replaced with a new entity.
- Automatic Deletion:
  - Orphaned entities are deleted automatically during the JPA flush or commit operation, without needing explicit calls to entity.remove()
- Difference from CascadeType.REMOVE:
  - CascadeType.REMOVE deletes child entities only when the parent is deleted.
  - orphanRemoval = true deletes child entities when they are no longer referenced by the parent, even if the parent remains in the database.
- Use Case:
  - Ideal for relationships where the child entity has no meaning without the parent (e.g., an Appointment without a Doctor or Patient, or an Insurance without a Patient).

Cascading in JPA Mappings

In JPA, cascading tells the persistence provider (like Hibernate) what operations to propagate from a parent entity to its related child entities automatically.

- CascadeType.PERSIST: Propagate persist (save) operation.
- CascadeType.MERGE: Propagate merge (update) operation.
- CascadeType.REMOVE: Propagate remove (delete) operation.
- CascadeType.REFRESH: Propagate refresh operation.
- CascadeType.DETACH: Propagate detach operation.
- CascadeType.ALL: Propagate all operations (PERSIST, MERGE, REMOVE, REFRESH, DETACH).

N+1 Query Optimization

- For **one to many** relations, the entity having **one-side** will be having a **List** of the entities of **many-side.**
- In this case, by default the fetching behaviour is **Lazy.**
- If you want to get all the things within the same object directly then you can use:
  - **fetch = FetchType.EAGER** (eager means it'll directly call **join query** and give you one object having all the objects of the referenced type(s))
- When you make this **FetchType.EAGER**, you can see there will be **N+1** queries; which is not optimized behaviour;

- **FetchType**
  - 2 types are there: **EAGER, LAZY**
    - In case of EAGER, child will be loaded immediately when parent is fetched.
    - In case of LAZY, child will only be loaded when we do **get** call from parent to get child data.
  - But sometimes we want both;
    - Like some method call may need full data i.e. parent and child in a single call.
    - And some method may not need full data; in this case making the Entity as **EAGER** will be very expensive; unnecessay a lot of data will be fetched from DB.
  - So, in this case we make the Entity **LAZY** and we'll do something in method call to control the type of fetching.
    - One thing can be done:
      - Fetch the parent
      - Use a loop or something like that to get all the child objects;
      - But, it'll result in **N+1** SQL queries; **1** for fetching *parent*, **N** for fetching *children* (considering N childs are there)
    - Instead of handling the FetchType from the Entity level, we'll do this from **method level**.
    - So, when the method needs full data EAGER type call will happen; otherwise LAZY by default;
  - 2 methods of controlling the fetching type from methods:
    - **FETCH** join JPQL query

```
@Query("select o from Order o join fetch o.items")
List<Order> findOrdersWithItems();
```

    - **@EntityGraph** annotation

```
@EntityGraph(attributePaths = "items")
@Query("select o from Order o")
List<Order> findOrdersWithItems();
```

      - "**items**" is object field name; not column name;
  -

Some Experiments

- Lets say 3 entities are there **E1, E2, E3;** some objects are **e1, e2, e3**.
  - **E1 to E3** : One-to-One mapping
  - **E2 to E3** : One-to-One mapping
  - **orphanRemoval** is **true** for **E3** field in both **E1, E2**.
  - Lets say I did: **e1.setE3(null)**
    - Just removing the reference of **e3** from **e1**.
  - But, **e1**'s reference is still there in **e2**.
  - But, in this case Hibernate will try to delete **e3** from DB because in **e1**, its reference is gone.
    - Then DB will give error saying its reference is still there in **E2** table.
  - So, its design failure; The design of Database is wrong here;
- Let say 2 entities are there **E1, E2**. **------ this is wrong; not sure why it happens -----**
  - **E1 to E2** : One-to-One
  - **orphanRemoval** is **true** for the ***E2 field*** in ***E1*** entity.
  - No **cascade** is there.
  - Lets say I delete **e1** (object of type E1) which had reference of **e2** (object of type E2).
    - Even there is no **cascade** there, but because of deletion of **e1** the reference of **e2** is gone; hence it'll delete **e2** as well.
- Ff
-

Some Error Causes

- ERROR-1
  - Consider the following codes:

```java
@Test
public void testAssignInsuranceToPatient() {
    Insurance insurance = insuranceRepository.findById(5L).orElseThrow();
    var updatedInsurance = insuranceService.assignInsuranceToPatient(insurance,  patientId: 7L);
}
```

```java
@Transactional  1 usage
public Insurance assignInsuranceToPatient(Insurance insurance, Long patientId) {
    // patient to insurance: one-to-one
    // insurance: owning, patient: inverse
    Patient patient = patientRepository.findById(patientId).orElseThrow();
    patient.setInsurance(insurance);

    // optional: if you want to use insurance object in this scope
    insurance.setPatient(patient);

    return insurance;
}
```

  - In this case you'll get an error like: "**detached entity passed to persist**"
  - In the first method i.e. *testAssignInsuranceToPatient*,
    - you are using **findById** to get the insurance.
    - So during this method call:
      - Spring opens a short lived EntityManager
      - Loads **Insurance**
      - Returns it
      - ***Closes the EntityManager***
    - Now, as the EntityManager is closed, so now **insurance** is in ***detached*** state now, not in ***managed*** (persistent context) state.
    - Now you are sending this ***detached*** object to next method i.e. *assignInsuranceToPatient* which is passing this object to *setInsurance***.**
    - So, in here, *setInsurance* expects one ***managed state*** object; but its gettnig ***detached state*** object;
    - Hence, it is giving that error.
  - Fix:
    - write **@Transactional** in the **@Test** method; Now, both the method will run in same EntityManager till the transaction is completed.

- If you are writing **@Transactional** in **@Test** method, then no need to write **@Transactional** in the *assignInsuranceToPatient* method. Only the **outer method needs to have @Transactional.**