Full-Text Search on localized items

Hibernate Search for full-text search on localization-related ORM entities

Software Architectures and Metodologies
Prof. Enrico Vicario

Francesco Areoluci

SWAM project 2020/2021

Project Overview

Project aim

The aim of the project is to address and investigate about the following problems:

1. Develop a **RESTful backend application** based on Java EE (JPA + CDI) to perform full-text search using the Hibernate Search library…

2. …on a logic domain that implements **internationalization/localization** of entities. Hibernate Search should manage indexing and searching of the localized Object Relational Mapped entities.

Project Overview

Internationalization and Localization [1]

- **Localization**, often referred as **l10n** where 10 is the number of letters between *l* and *n*, is the process of **adapting** a product, an application or a textual document to a specific country or region.

- The process of localization of a product or application can be easily enabled through the process of internationalization.

- **Internationalization**, often referred as **i18n** where 18 is the number of letters between *i* and *n*, is the process of design and development of a product or application that enables **easy localization**.

Project Overview

Hibernate Search [2]

- Enabling technology for **indexing** and **full-text search** on Hibernate applications. It allows to extract data from hibernate ORM entities and push it to local or remote indexes.
- Hibernate Search is particularly useful for applications where SQL-based searches are not suited, such as full-text and geolocation searches.
- The search is based on the concept of **inverted indexes**: a dictionary where the key is a token found in a document and the value is the list of identifiers of every document containing that token

Project Overview

Hibernate Search

- Hibernate Search backend module **abstracts the full-text search engine**, by implementing indexing and searching interfaces.
- Provides abstractions based on two popular full-text search libraries: **Lucene** (local indexing) and **Elasticsearch** (remote indexing).

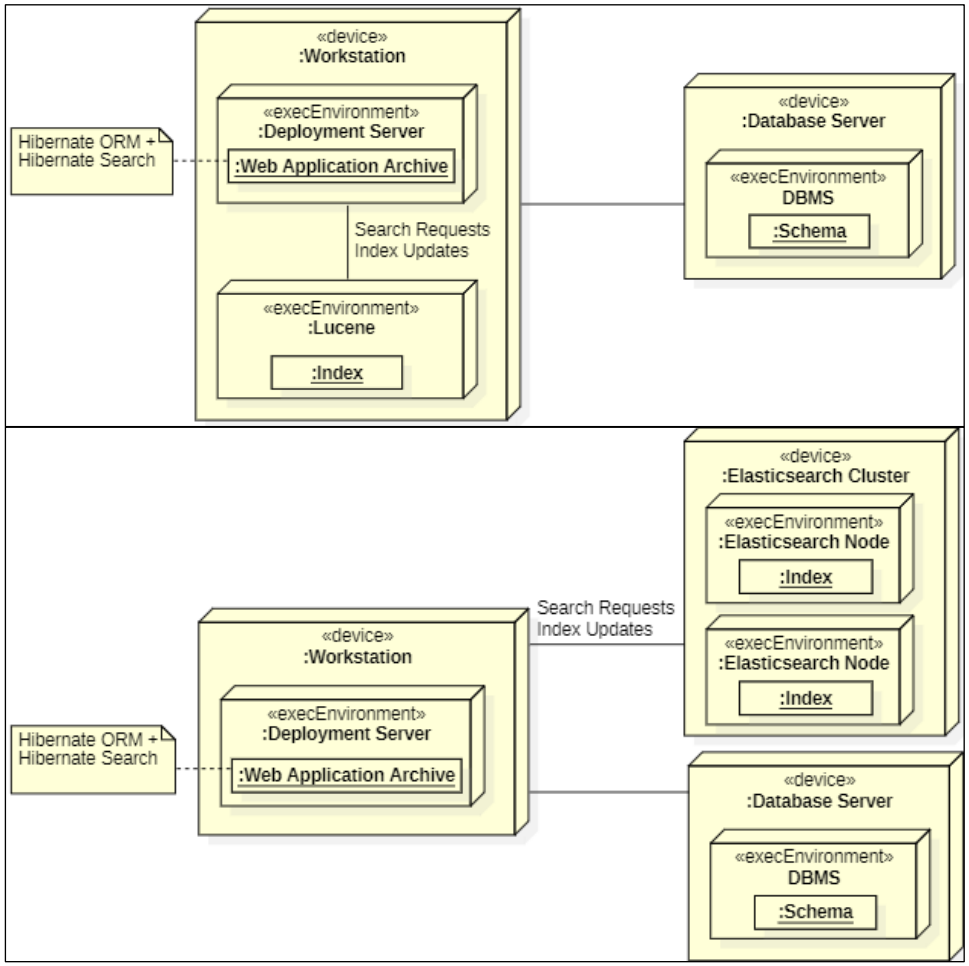


***Figure 1**: Hibernate Search integration with Lucene (top) and Elasticsearch (bottom) backends*

Context of application

Full-text search on localized entities

- The developed application represents the backend of an online shop which let the users **purchase products** and **search for them through query** on their name and/or description.
- **Products fields**, such as name and description, must be **localized in multiple locales**: English and Italian.
- Through this application, Hibernate Search functionalities can be used on product's localized attributes: these **fields in multiple languages will be used by Hibernate Search** to retrieve matching entities.
- The system should offer its functionalities through a **RESTful interface** using the **JAX-RS** specification.

Workflow

Steps

The project objectives have been accomplished through the following workflow:

1. Software Requirements Specification;
2. Use Cases Design;
3. Domain Model Design;
4. Packages Modeling
5. Endpoints Resources Design + Data Contract Definition;
6. Sequence Diagrams Design;
7. Application development and testing

Workflow

Software Requirements Specification

Requirements have been designed in order to define **what operations the system should do and how these operations should be accomplished**. To do that, four types of requirements have been used:

- **Functional** Requirements;
- **Non-functional** requirements;
- **Domain** requirements;
- Project **constraints**

Workflow

Software Requirements Specification

- **FR1**: The system must allow to manage the available products
- **FR2**: Each product must contains the following fields:
  - **FR2.1**: Product Name
  - **FR2.2**: Product Description
  - **FR2.3**: Price
  - **FR2.4**: Manufacturer
  - **FR2.5**: Product category
- **FR3**: The system must have the localization feature: products must be localized in multiple langauges (it, en). Localization feature must be used on the following fields:
  - **FR3.1**: Product Name
  - **FR3.2**: Product Description
  - **FR3.3**: Price
  - **FR3.4**: Product Category
- **FR4**: The system must allow the visualization and purchase of the products.
  - **FR4.1**: The product visualization must be localized: a product must be returned to the user with fields specified in FR3 properly localized.
- **FR5**: The system must features the search on products.
- **FR6**: The system must features the management of two types of user account
  - **FR6.1**: Administrator account - Responsabilities: Product management and research, as specified in FR1 and FR5
  - **FR6.2**: Customer account - Responsabilities: Product research and purchase, as specified in FR4 and FR5

***Figure 2**: Application Functional Requirements*

Workflow

Software Requirements Specification

- **NFR1** (Security Requirement): Application access must be managed through user authentication for all the account types described in FR6.
- **NFR2** (Implementation Requirement): The purchase functionality, as specified in FR4, must be prototyped as following:
  - **NFR2.1**: The user must have a shopping cart. The user can add and remove products to/from the cart;
  - **NFR2.2**: Once the user has added to the cart the desired prodcuts, he/she can proceed to the checkout. This operation will move the cart products to a shopping list. The cart will be cleared.

***Figure 3**: Application Non-Functional Requirements*

- **DR1**: The product management, as specified in FR1, must allow to add, remove and edit the products (CRUD operations)
- **DR2**: The products search, as specified in FR5, must be based on query keywords and must be used to search on products' name and description.
- **DR3**: A customer account must have an associated locale in order to implement the product visualization feature.

***Figure 4**: Application Domain Requirements*

Workflow

Software Requirements Specification

- **C1**: The application must be developed using Java EE, with JPA and CDI technologies.
- **C2**: The Persistence layer must be managed using Hibernate.
- **C3**: The persistence must be managed by DBMS MariaDB.
- **C4**: The search layer must be manager through Hibernate Search library.
- **C5**: Application services must be exposed via REST API using JAX-RS technology.
- **C6**: Package management must be managed through Maven.

***Figure 5**: Project constraints*

Workflow

Use Cases Design

- Use Case Design has allowed to formalize the actions that each actor (**customer** or **administrator**) is allowed to do within the application.
- Each action can include or be extended by other actions.

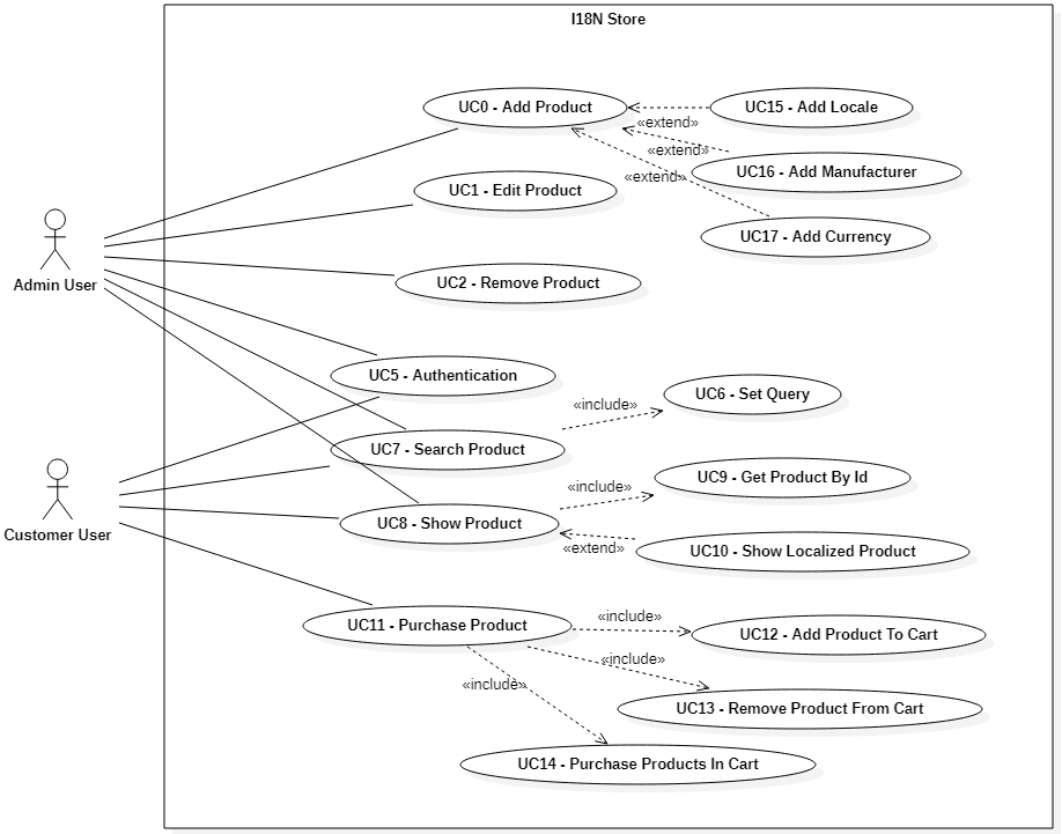


***Figure 6**: Application use cases*

Workflow

Domain Model Design

Using the requirement specification and the use cases modeled in the previous steps, the Domain Model has been designed through **UML Class Diagrams**.

- The designed **Domain Model** specifies the entities representing the domain of the application

- This model can be extended through the designed **Translation Model**, which contains the components responsible for the **translation of the domain model entities**

Workflow

Domain Model

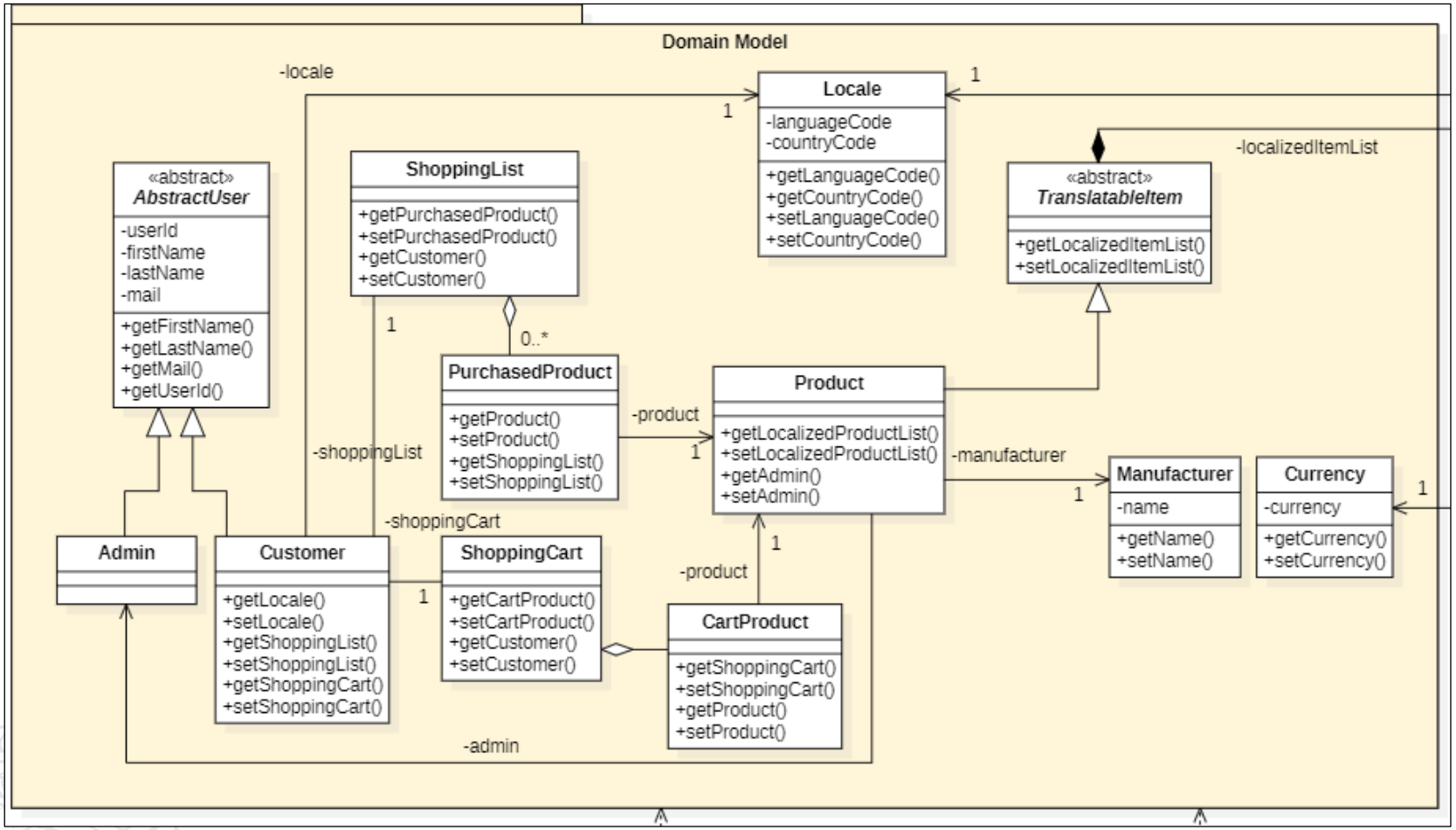


***Figure 7**: Domain Model package class diagram*

Workflow

Translation Model

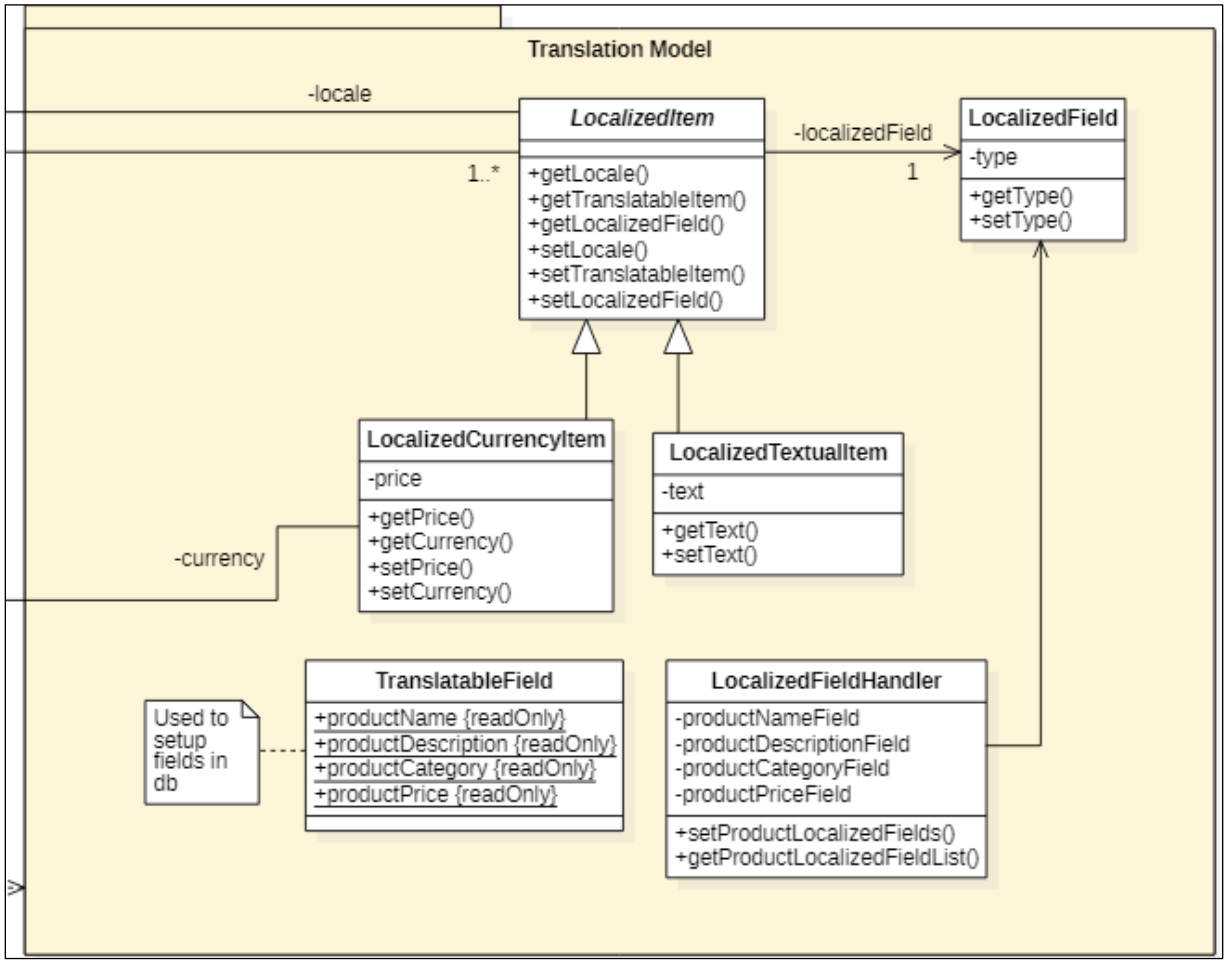


***Figure 8**: Translation Model package class diagram*

Workflow

Packages Modeling

Then, the entire application logic has been designed through UML class diagrams in order to wrap the domain model and the translation model in a **three-tier architecture**.
To do that, the application model has been divided in **packages**, one for each logic domain:

- **Domain Model + Translation Model:** previously presented
- **Rest**: contains the available controllers (endpoints)
- **Data Access Objects**: entities responsible for DBMS interaction and instantiation of domain model entities
- **Data Transfer Objects**: entities used to transfer data from endpoints to client and viceversa
- **Security**: entities responsible for user authentication and authorization management

Workflow

Application Class Diagram Summary

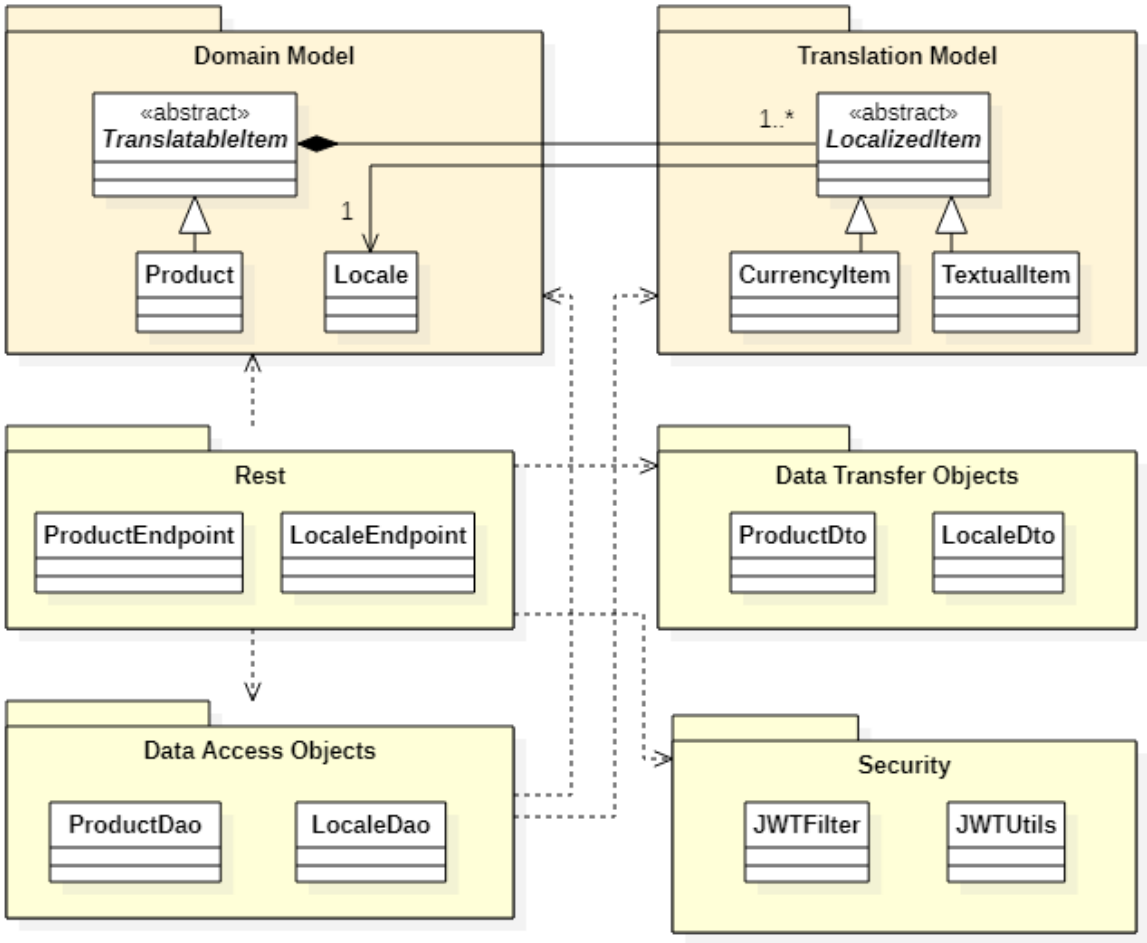


***Figure 9**: Basic UML class diagram representing the relationships between packages*

Workflow

DAO Package

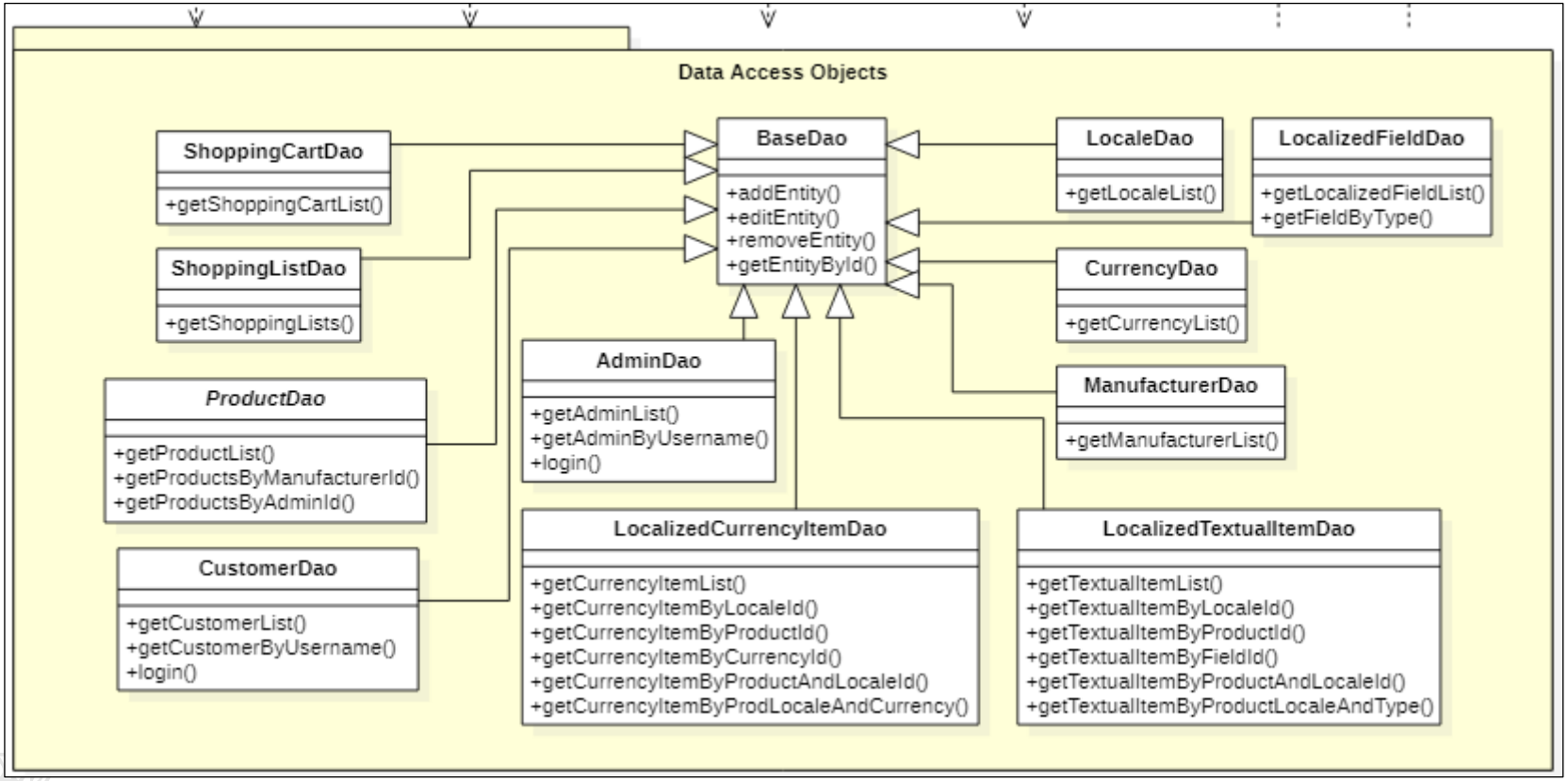


***Figure 10**: Data Access Object package class diagram*

Workflow

Rest Package

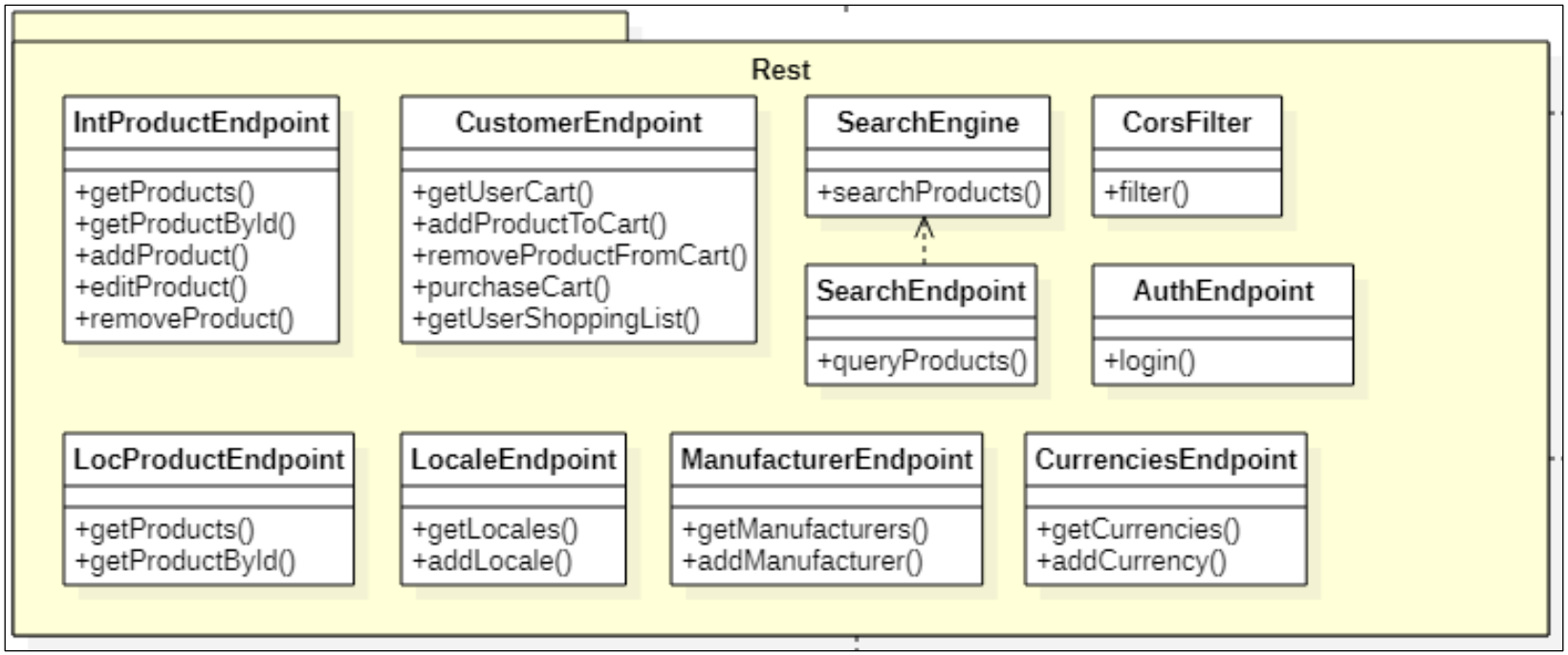


***Figure 11**: Rest package class diagram*

Workflow

Security Package

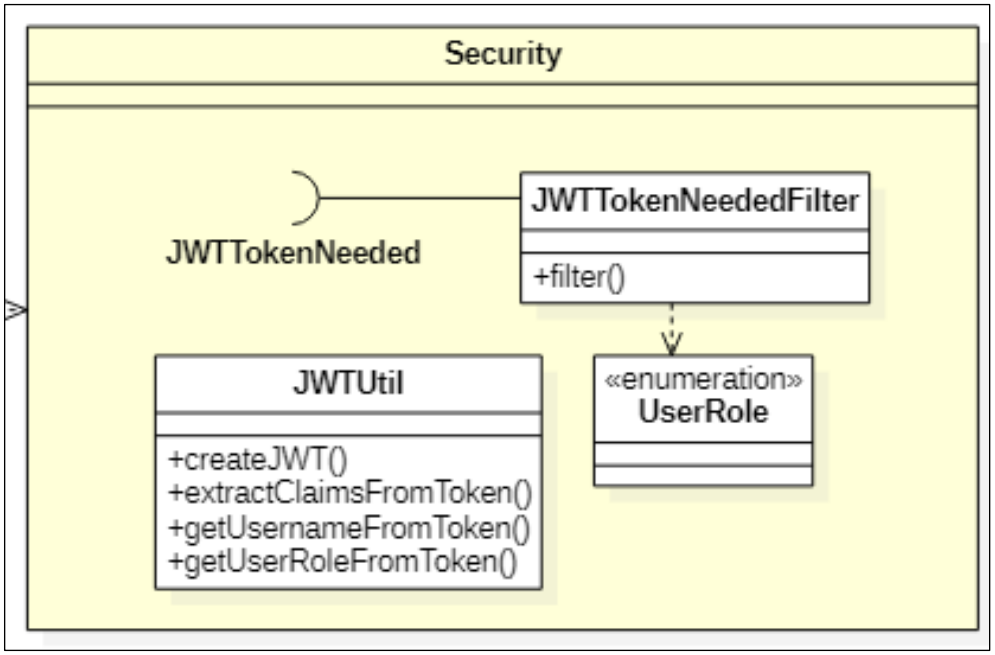


***Figure 12**: Security package class diagram*


```
{
  "subject": "mario.rossi@example.com",
  "issuedAt": 1624223874036,
  "userId": 1,
  "userRole": "ADMIN",
  "lang": "en",
  "exp": 1624224474,
  "issuer": "i18n-store"
}
```


***Figure 13**: Exchanged Json Web Token [3] payload*

Workflow

E-R Model

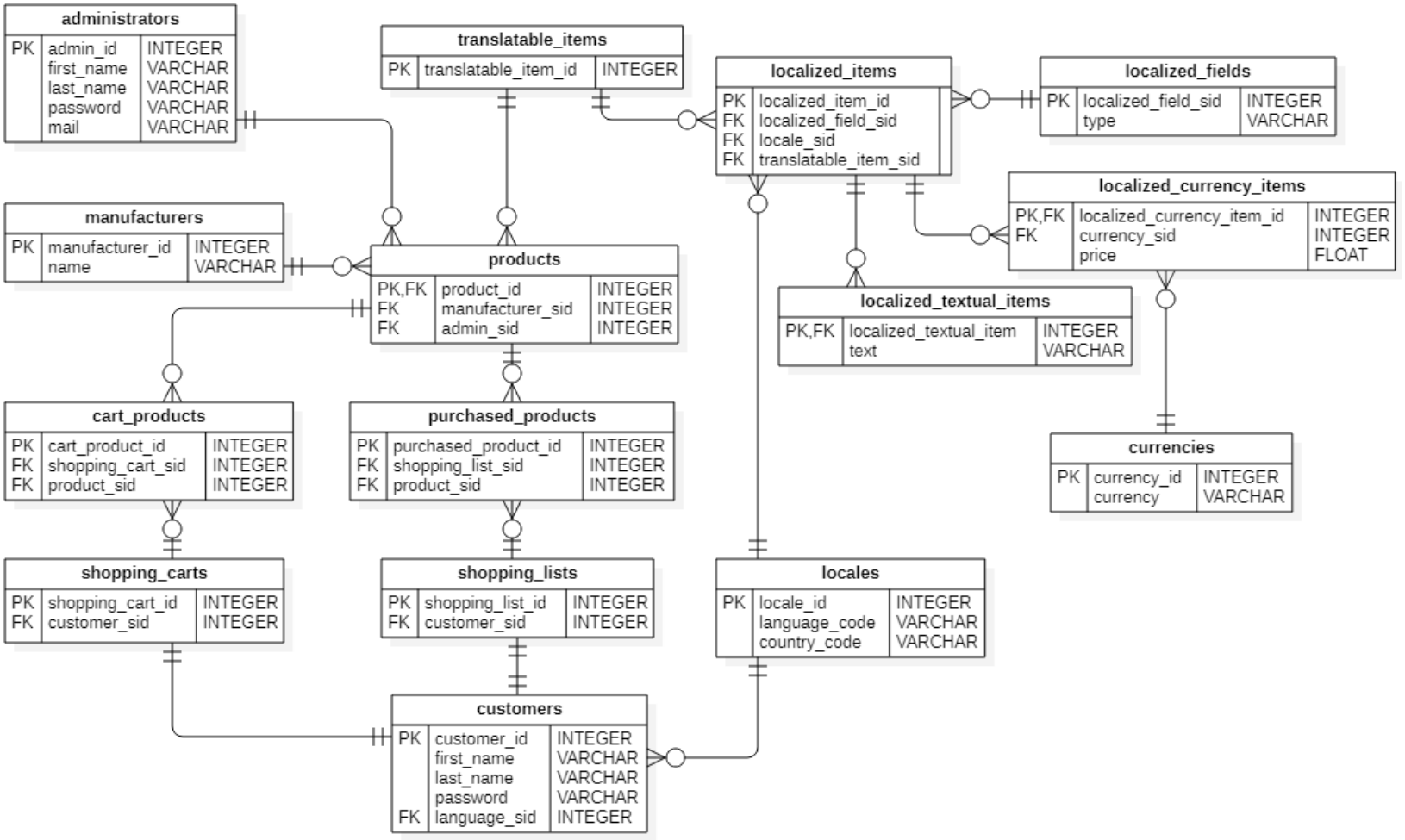


***Figure 14**: I18N-Store Entity-Relationship model*

Workflow

Endpoints Resources Design + Data Contract Definition

The following groups of **REST APIs** have been modeled in order to let the clients use the system functionalities:

- **Authentication** endpoint
- **Administration** endpoints
- **Customer** endpoints
- **Search** endpoints

Each group contains a set of endpoints that allows to manage products (administration) and purchase them (customer). Authentication and search are common functionalities that can be used by both types of users.

Workflow

Endpoints Resources Design + Data Contract Definition

- **GET /api/auth/login**: User authentication, sent JWT to user if given username and password are correct

***Figure 15**: Authentication endpoint*

- **GET /api/users**: Show all the users
- **GET /api/int-products**: Show all the internationalized products (along with all localizations)
- **GET /api/int-products/{prodId}**: Show specified internationalized product (along with all localizations)
- **POST /api/int-products**: Add an internationalized product
- **PUT /api/int-products/id**: Edit an internationalized product
- **DELETE /api/int-products/{prodId}**: Remove an internationalized product
- **GET /api/locales**: Show all configured locales
- **POST /api/locales**: Add a locale
- **GET /api/manufacturers**: Show all manufacturer
- **POST /api/manufacturers**: Add a manufacturer
- **GET /api/currencies**: Show all currencies
- **POST /api/currencies**: Add a currency

***Figure 16**: Administration endpoints*

Workflow

Endpoints Resources Design + Data Contract Definition

- **GET /api/products**: Show all products, localized in user locale
- **GET /api/products/{prodId}**: Show specified product, localized in user locale
- **GET /api/customer/{userId}/shopping-cart**: Show user shopping cart
- **POST /api/customer/{userId}/shopping-cart/{prodId}**: Add specified product to user shopping cart
- **DELETE /api/customer/{userId}/shopping-cart/{prodId}**: Removed specified product from the user shopping cart
- **POST /api/customer/{userId}/shopping-cart/checkout**: Purchase all the product in shopping cart and move them to the shopping list
- **GET /api/customer/userId/shopping-list**: Show user shopping list

***Figure 17**: Customer endpoints*

- **GET /api/kw-products?query={query}**: Search products according to their name and description with a query (keyword separated by "+" character)
- **GET /api/mlt-products?like={id}**: Search products similar to the one specified by the given identifier

***Figure 18**: Search endpoints*

Workflow

Sequence diagrams

Through sequence diagram, specific actions of use cases can be modeled to **describe exchanged messages between the entities** in order to accomplish the specific operation.

The following sequence diagrams have been created:

- Add Product
- Show Product
- Add Product To Cart
- Purchase Products

Workflow

Sequence diagrams

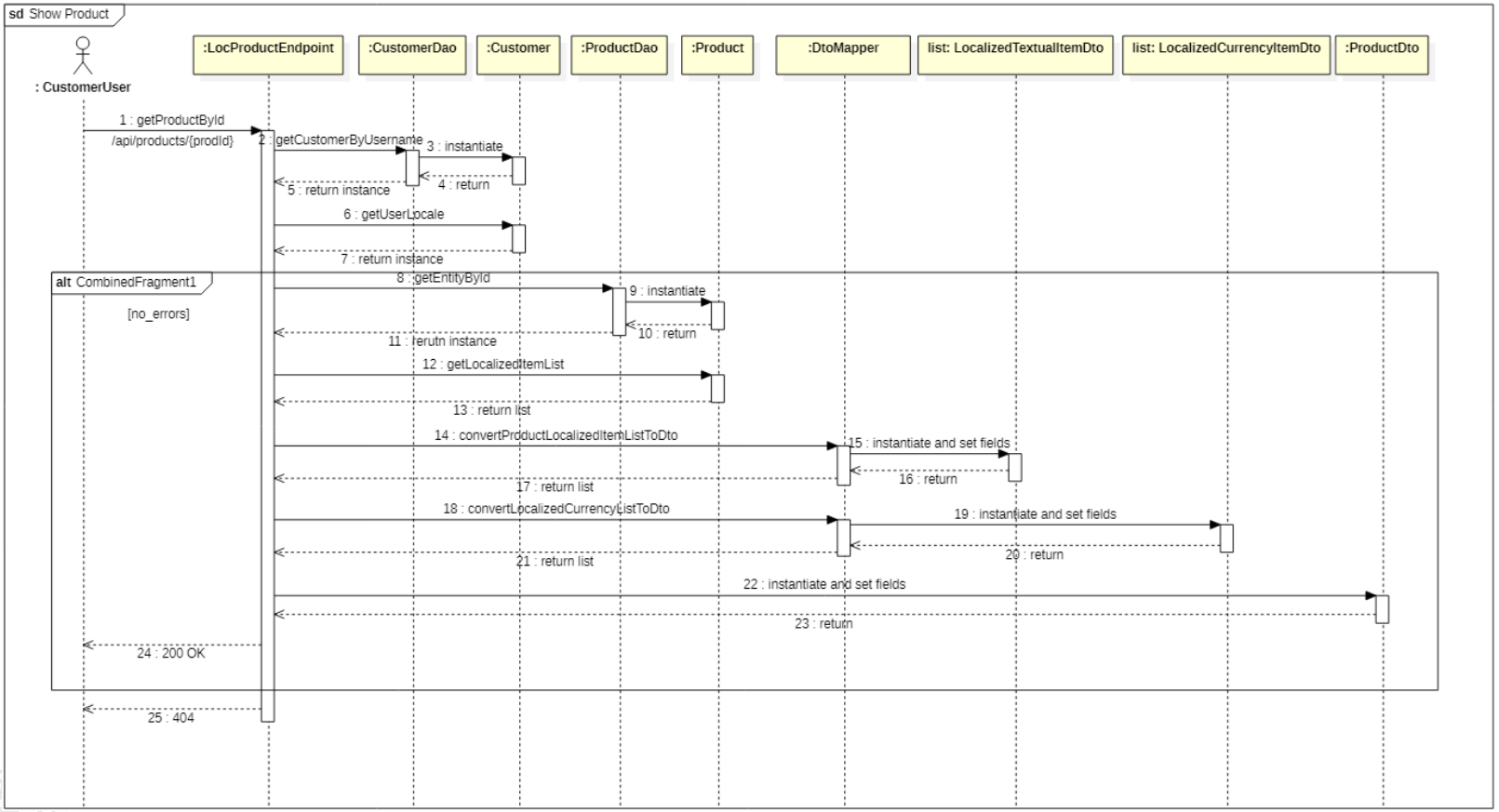


***Figure 19**: Show product sequence diagram*

Workflow

Application Development

After the design, the application has been developed by implementing each package using the requested technology stack (JPA, CDI, JAX-RS, Hibernate Search).

The following functionalities have been implemented:

- **Administration**: add, edit and remove a localized product, manage application locales and currencies, show users and manufacturers, show products with all their localizations;
- **Customer**: show product localized in user locale, purchase products through the use of a shopping cart;
- **Common**: Authentication, product search by keywords and similarity through Hibernate Search.

Workflow

Implemented search functionalities

The following functionalities have been implemented with Hibernate Search:

- **Startup indexing**: a bean is responsible of the indexing made at startup time
- **Standard OR search**: searches on the inverted index using an *OR query*
- **Standard AND search**: searches on inverted index using an *AND query*
- **Fuzzy search**: approximate matching with *Levenshtein distance*
- **Phrase search**: search for exact or approximate *sentences*
- **Similarity search**: search for entities *similar* to the requested one

Workflow

Application Testing

Application development has been supported by test units.

Tests have been developed for the following package using the **JUnit** [4] **framework**:

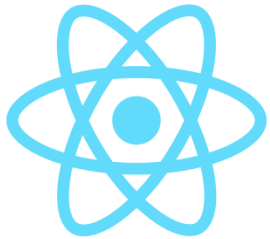
- Model (domain + translation)
- Dao
- Dto
- Security

Controller endpoints have been tested through the use of **Postman**, by creating a collection of REST call that can be run to test the correctness of returned values and the error handling

Frontend Application

React Redux

- A **demonstrative frontend application** has been developed to consume the offered REST APIs and to show the functionalities of the backend application.
- The frontend application has been developed using the **React** [5] framework with the **Redux** [6] library.
- React allows to easily build user interfaces and thanks to Redux the MVC architecture can be implemented.



Frontend Application

Frontend pages

The following frontend sections have been implemented:

Administration section:

- **Products**: show all the available products and all their configured localizations. Products can be added, modified and removed.
- **Users**, **Locales**, **Manufacturers**, **Currencies**: these pages shows the respective configured values

Customer section:

- **Products**: available products, localized in customer locale
- **Shopping Cart**: allows to purchase products
- **Shopping List**: show purchased products

The user interface has been **internationalized** through the use of **i18next** library

Frontend Application

Angular vs React Redux

Angular	React + Redux
● TypeScript based	● Javascript based
● Components can communicate by passing data to each others	● Components can communicate by passing data to each others
● Components splitted in three parts: HTML (view), TS file (logic), CSS (style)	● Components implement render methods (view) and handle the logic
● Various component lifecycle hooks	● Various component lifecycle hooks
● Data model can be defined thanks to TypeScript	● No standard data model definition in React vanilla. Centralized state with Redux
● Services as controllers	● No standard controller definition in React vanilla. Actions + Dispatchers with Redux

***Figure 20**: Comparison between Angular and React frameworks*

Frontend Application

Angular vs React Redux

```
class ShoppingList extends React.Component {
    constructor(props) {
        super(props);
    }

    componentDidMount() {
        this.props.getShoppingList();
    }

    render() {
        return (
            <div className="shopping-list-container">
                <div className="shopping-list__title">
                    Shopping List
                </div>
                {this.props.shoppingList.products.map((p, i) =>(
                    <ProductCard
                        prodId={p.id}
                        name={p.name}
                        manufacturer={p.manufacturer}
                        price={p.price}
                    />
                ))}
            </div>
        );
    }
}
```

```
class ProductCard extends React.Component {
    constructor(props) {
        super(props);
    }

    render() {
        return (
            <div className="product-card">
                <div className="product-card__name">
                    {this.props.name}
                </div>
                <div className="product-card__manufacturer">
                    {this.props.manufacturer}
                </div>
                <div className="product-card__price">
                    {this.props.price}
                </div>
            </div>
        );
    }
}
```

***Figure 21**: Basic Shopping List (left) and Product Card (top) components built with React. Redux action (getShoppingList function) and centralized object (shoppingList.products) omitted for brevity.*

Frontend Application

Angular vs React Redux

```
class ShoppingListComponent implements OnInit {
  products: ProductInfo[] = [];

  constructor(private shoppingListService: ShoppingListService) { }

  ngOnInit(): void {
    this.getShoppingList();
  }

  getShoppingList(): void {
    this.shoppingListService.getShoppingList()
      .subscribe(products => this.products = products)
  }
}
```

```
<div class="shopping-list-container">
    <div class="shopping-list__title">
        Shopping List
    </div>

    <div *ngIf="products">
        <div *ngFor="let product of products">
            <app-product-card [product]="product"></app-product-card>
        </div>
    </div>
</div>
```

```
class ProductCardComponent implements OnInit {
    @Input() product?: ProductInfo;

    constructor() { }
}
```

```
<div class="product-card">
    <div class="product-card__name">
        Product Name: {{product.name}}
    </div>
    <div class="product-card__manufacturer">
        Manufacturer: {{product.manufacturer}}
    </div>
    <div class="product-card__price">
        Price: {{product.price}}
    </div>
</div>
```

***Figure 22**: Basic Shopping List (left) and Product Card (top) component built with Angular. Service (getShoppingList function) and ProductInfo interface omitted for brevity.*

Conclusions

- The developed prototype application is a **shop designed with internationalization features**: shop products can be easily localized in multiple languages.
- Thanks to the **Hibernate Search** library, **full-text search** feature on these localized items has been implemented. **Various types of search** can be accomplished, from simple standard searches to similarity searches.
- Application development leaded by **design** and **testing** stages.
- A **demo frontend application** has been developed using **React Redux**. The frontend application allows to use the main functionalities of the backend.

References

1. Internationalization/Localization:

   https://www.w3.org/International/questions/qa-i18n
2. Hibernate Search:

   https://docs.jboss.org/hibernate/search/5.10/reference/en-US/html_single
3. Json Web Tokens: https://jwt.io/
4. Junit: https://junit.org/junit5/
5. React: https://it.reactjs.org/
6. Redux: https://react-redux.js.org/