



JustRecipe

*Group Project for Large Scale and Multi-Structured
Databases*

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Introduction

In the social network era the large scale databases topic is very relevant. The handling of big data such as informations of users and moreover is a critical asset of our society. In fact, from the viewpoint of the security is very important to handle in the correct way this very huge amount of data because, otherwise, it is possible to have leak of critical information that cause critical issues about user's privacy.

Another problem caused from large amount of data created from the applications used every day from all of us, is the following: *How we can manage this data?*

Nowadays we have a lot of tools to do this, the most famous, and maybe the most used, is for sure MongoDB. It allows us to handle a huge amount of data without critical issues and maintaining good performance. Another well-known tool is Neo4J that is in charge of handle the social part of the application, in fact the graph is indeed a network, and so this is the best way to represents a social network where the interactions between users are fundamental and very widespread.

Our aim is to design and implement a modern application which can handle a huge amount of data maintaining good performance and implementing a social network side in order to exploit the desire of social relations of our society.¹

¹The github repository of the project is at the following link: <https://github.com/danielecioffo/JustRecipe.git>

Chapter 1

Dataset

In this first chapter of this document we will talk about searching for the initial dataset.

As specified in the project documentation, the dataset had to be at least 50MB large, and this quantity could not be generated directly within the application. So we did an initial search, finding two datasets, which were generated by their authors¹ by performing the scraping on the sites *www.FoodNetwork.com* and *www.Epicurios.com*. The second dataset was more complete (more nutritional values), so it was used as the main dataset. The other dataset was used to complement the other, reaching a total of 67.8 MB, with 45348 recipes.

To correctly extract the data present in the two datasets we wrote a program in Java, called *RecipeReader*, thanks to which we adapted the two different formats and removed the duplicates (recipes with the same title that were present in both datasets). To implement this program we used the GSON library and the Jackson library.

The variety property is ensured by using two different sources. The velocity/variability properties are ensured because comments and recipes are eliminated and added inside the application, indeed this data may lose importance after a certain time interval since new data quickly arrives.

¹ <https://eightportions.com/datasets/Recipes/>
https://www.kaggle.com/hugodarwood/epirecipes?select=full_format_recipes.json

Chapter 2

Design

2.1 Introduction To The Application

The topic of cuisine is extensively widespread in our society. In fact we can think at the success achieved by tv shows related to cooking in the last years and also at the fact that a lot of chefs are becoming superstars. Then there is another important factor: the coronavirus outbreak.

With the coronavirus outbreak a lot of people became cuisine lovers, in fact at the first moments of the pandemia several ingredients as flour and yeast were very hard to find, because people were confined in their home and so they had more free time.

But this topic is not a recente one. The first recipe book dates back to eighth century B.C. and it is the so-called *Eraclio* (by the name of the city in which it was found). Then also an important latin writer, Apicio, wrote one of the most important recipe books of the roman era: *De Re Coquinaria* which dates back to the first century B.C..

So the topic of cuisine is inherent to human nature, because the necessity of eating is a basic need. Furthermore, everyone has experimented the infamous question: “What will I eat this evening?”. JustRecipe has the aim of answer to this question, it has the aim of helping university student or workers to retrieve and to do fast and simple recipes.

So this application is basically a recipe book but it is also more than this.

JustRecipe is also a social network which allow people to enjoy, to ex-change ideas about cooking, to feel less lonely in this hard period.

2.2 Requirements

2.2.1 Main Actors

The main actors of the application are four:

- Unregistered User
He is the user which opens the application for the first time, in order to access he must sign-up.
- User
He is the normal user (the registered one).
- Moderator
He is in charge of controlling the comments and eventually delete the ones which contain abuses.
- Administrator
He is the most powerful actor, he can delete users and recipes and he is also in charge of elect moderators and others administrators. When a user becomes administrator, this privilege cannot be revoked.

Each actor can do all the features of the previous ones in the list.

2.2.2 Functional Requirements

Features offered to the Unregistered User

- Registration

In order to access the application an user must sign-up. Otherwise he is not allowed to access and to use all the functionalities.

Features offered to the Registered User

- Login/Logout

The only way to access the application, as we said previously, is to sign-up and login. At the end the user can logout and close the session.

- Search a recipe

It's possible to search a recipe searching for the title and for categories.

- Browse suggested recipes

The suggestions will be offered in a proper section, they are done considering the relationships between the user logged, the users followed by the user logged and so on so forth.

- Browse recipes of following users

In a proper section (i.e. the Homepage) the user can browse the recipes of the following users. Indeed he can see only a snapshot of the recipes. If he wants a more in-depth view, he can click on it and see the recipe page in which he is able to see all the recipe details.

- Add a recipe

The user can insert a new recipe.

- Edit own recipes

The user can edit the recipes previously added by himself.

- Comment recipes

Every user can make a comment about recipes

- Follow another user

The most important feature of each social network: the users can follow each others.

- Like a recipe

In order to evaluate a recipe each user can like it.

Features offered to the Moderator

- Delete comments

The moderator is in charge of delete comments which contain racist abuse, crude terms and so on so forth.

Features offered to the Administrator

- Delete users

The admin can delete the users which don't respect the application guidelines.

- Delete recipes

The admin can delete recipes not correctly inserted

- Elect/Dismiss moderators

In order to handle better the application, the admin can elect some users as moderators.

- Elect administrators

The admin can elect other administrators.

2.2.3 Non-Functional Requirements

The non-functional requirements of the applications are described in the following lists:

- *Usability*: The application must be user-friendly so a GUI is adopted. A low response time is necessary in order to avoid too long waits for the user.
- *Availability*: For modern shared-data systems and for a social network application, the most crucial requirement is that the service must be always available.
- *Data Consistency*: The operations must be monotonic and so all the users must see the last version of the data and the update operations must be performed in the same order in which they are issued.
- *Reliability*: The application must work without crashes and so it must handle exceptions if they occur.
- *Flexibility*: Due to the fact that the recipes attribute are not all mandatory, the data must be handled in a flexible way.

2.2.4 Actors and Use Cases

The use case diagram of the application is described in the figure 2.1



Figure 2.1: Use Case Diagram

Some observations on the diagram are necessary:

- The circles in blue are the ones which described actions available only for the owner of the object on which the actions are applied.
- So, in detail, this means that a **User** can edit/delete a profile if and only if he owns this profile. Then he can edit a recipe and/or a comment if and only if he adds that recipe or that comment.
- When we are seeing the recipe detail we can go on the user that has been added that recipe. So the extend relation between *View Recipe* and *View User* means this.
 - The action *Recipes of following users* is available only if the **User** follows at least one user.
 - In case there are no suggestions the user will see the most famous recipes in general.
 - The actions in red are the ones that can be performed only by the **Administrator**

- The actions in orange are the ones that can be performed only by the **Moderators**

2.3 UML Class Diagram

Let analyze the UML Class Diagram. There are three main entities: User, Comment, Recipe. It's important to point out that the **User** of the Use Case Diagram is here the so-called *Registered User* and the *User* of this diagram is the generic user. Then we underline the fact that, in order to represent the three actors of the use case diagram, a generalization is needed.

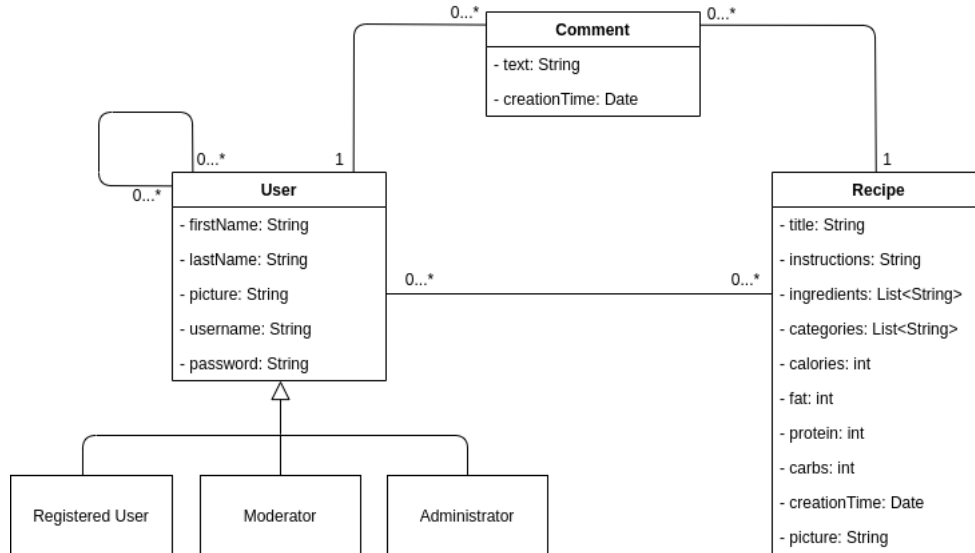


Figure 2.2: UML Analysis Classes Diagram with generalization unsolved

Observing the figure 2.2 it's possible to understand that we can resolve the generalization putting an attribute in the entity *User*. It is an integer and we call it *role*: if it's a *Normal User* role is 0; if *Moderator* then 1; if *Administrator* then 2.

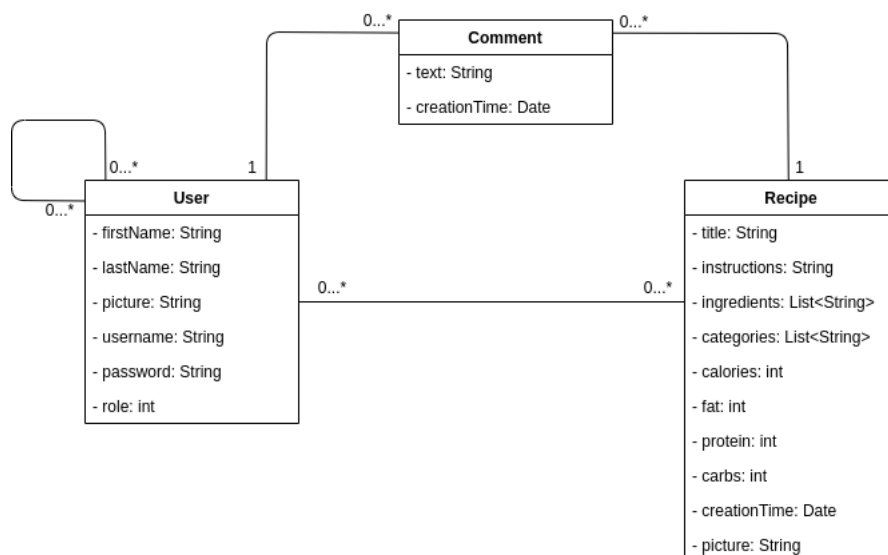


Figure 2.3: UML Analysis Classes Diagram

Let analyze the attributes for each class in the following tables.

Table 2.1: Classes definitions

Class	Description
Registered User	A standard user (registered one) who can only perform basic operations
Moderator	User who can also check comments and decide to delete them
Administrator	Most powerful user, he can also delete users and recipes, and elect moderator
Comment	Comment posted by a user
Recipe	Recipe added by one user

Table 2.2: Classes attributes - User

Attribute	Type	Description
firstName	String	First name of the user
lastName	String	Last name of the user
picture	String	URL of the picture
username	String	Username of the user (identifier)
password	String	Password chosen by the user, used for the login phase
role	int	Role of the user (0: Normal User, 1: Moderator, 2: Administrator)

Table 2.3: Classes attributes - Comment

Attribute	Type	Description
text	String	Plain text of the comment
creationTime	Date	Creation timestamp of the comment

Table 2.4: Classes attributes - Recipe

Attribute	Type	Description
title	String	Title of the recipe (identifier)
instructions	String	Operation to be performed to make the recipe
ingredients	List<String>	Ingredients to be used in the recipe
categories	List<String>	Categories to which the recipe belongs
calories	int	Calories contained in the recipe
fat	int	Fat contained in the recipe
protein	int	Protein contained in the recipe
carbs	int	Carbs contained in the recipe
creationTime	Date	Creation timestamp of the recipe
picture	String	URL of the recipe picture

2.4 Data Model

In this section we will discuss about the design choices performed in terms of data model in order to handle in the better way our dataset.

2.4.1 DocumentDB

The document database is used in order to deal with a very large amount of data in an easy and fast way. So due to the fact that our dataset is very large this is the best design choice to achieve the *usability* requirement, in particular for what is related to the latency. Moreover, we use a DocumentDB in order to respect the *flexibility* requirement, in fact it is schema-less and this allow us to maintain heterogeneous recipes in our database. For instance the user can insert a recipe without some attributes (carbs and fat for example) and we have no issues due to the schema-less property of DocumentDB. Furthermore this is very important for what concern the comments: in fact comments are embedded in the recipe document and the schema-less approach allow us to add comment in a flexible way and to have recipes without comments. So, to summarize, we use only one collection, *recipes*, in which every document is a recipe that contains also the comments. So this is how we decided to implements the *one-to-many* relationship between *Recipe* and *Comment*.

This is an example of one Recipe that contains all the values (this is not mandatory, like we said before):

```
1 {
2   "_id":
3     {"$oid": "5fdb5fd86796ee4e73ef5b84"},
4   "title":
5     "Lentil, Apple, and Turkey Wrap ",
6   "instructions":
7     "1. Place the stock, lentils, celery, carrot, thyme, and
8     salt in a medium saucepan and bring to a boil. Reduce heat
9     to low and simmer until the lentils are tender, about 30
10    minutes, depending on the lentils. (If they begin to
11    dry out, add water as needed)... " ,
12   "ingredients":
13     ["4 cups low-sodium vegetable or chicken stock", "1 cup
14     dried brown lentils", ...],
15   "categories":
16     ["Sandwich", "Bean", "Fruit", "Tomato", "turkey", ...],
17   "calories":
18     426,
19   "fat":
20     7,
21   "protein":
22     30,
23   "carbs":
24     20,
25   "creationTime":
26     {
27       "$date": "2020-12-17T13:40:40.658Z"
28     },
29   "authorUsername":
30     "oscar.evans",
31   "picture":
32     "https://assets.epicurious.com/photos/551
33     b0595e7851a541a30b23f/master/pass/239173_lentil-apple-
34     and-turkey-wrap_6x4.jpg",
35   "comments":
36     [
37       {
38         "author": "oscar.evans",
39         "text": "This recipe is amazing! I love the combination of lentils and turkey.",
40         "timestamp": "2020-12-17T13:40:40.658Z"
41       }
42     ]
43 }
```

```

35     "authorUsername": "oliver.smith",
36     "text": "Very good!!!",
37     "creationTime":
38     {
39         "$date": "2020-12-17T13:50:40.658Z"
40     }
41 },
42 {
43     "authorUsername": "jessica.evans",
44     "text": "Fantastic",
45     "creationTime":
46     {
47         "$date": "2020-12-17T13:52:40.658Z"
48     }
49 }, ....
50 ]
51 }

```

2.4.2 GraphDB

The Graph database is the one that handles the social part of the application. Thanks to it we are able to analyze the relationships among users and their recipes.

We have two type of nodes within the database:

- **User:** it is the node that represents the user inside the graph. Its attribute are: *firstName*, *lastName*, *username*, *password*, *picture*¹, *role*².
- **Recipe:** it is the node that represents the recipe within the graph. Its attribute are: *title*, *calories*, *fat*, *carbs*, *protein*, *picture*¹

The information about the user are present only on the GraphDB because we handle the social part only with it. Instead some information about recipes are present in both databases, in particular on GraphDB we have info that are already present also in the DocumentDB, but the opposite is not true.

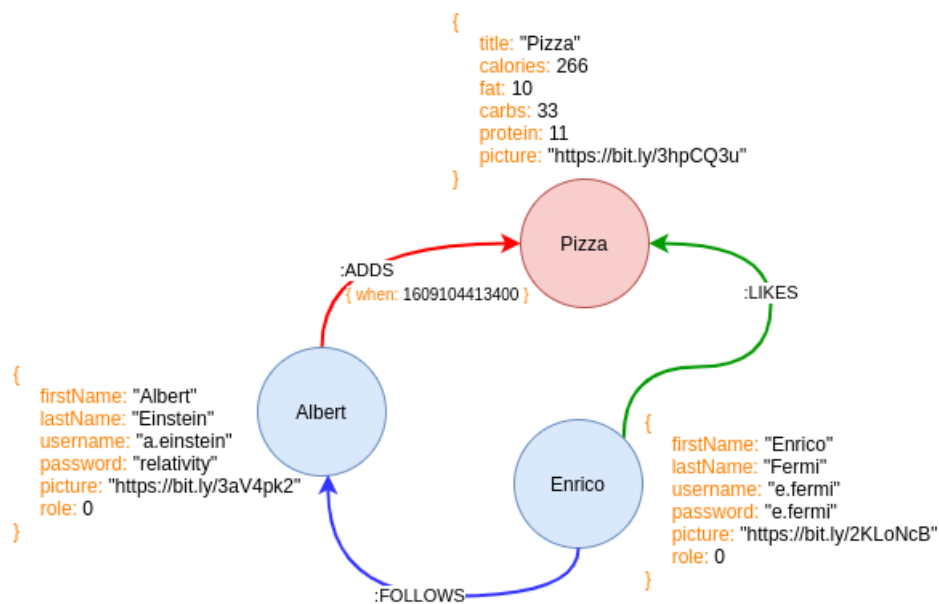


Figure 2.4: Example of GraphDB nodes and relationships

¹Only the URL of the picture is saved in this field, otherwise the size of this attribute would be too large

²0 for the normal user, 1 for moderator and 2 for the administrator

The GraphDB relationships are:

- **Adds:** if the user A has added the recipe R , then we have a relationship $:ADDS$ from A to R ($A \rightarrow R$).
We have as property, the one called *when* that is the timestamp which indicates when the recipe has been added.
- **Follows:** if the user A has followed the user B , then we have a relationship $:FOLLOWS$ from A to B ($A \rightarrow B$).
- **Likes:** if the user A has liked the recipe R , then we have a relationship $:LIKES$ from A to R ($A \rightarrow R$).

All the relationships that starts from a node X are deleted if X has deleted, furthermore if X is a user, also the recipes that he has added will be eliminated. In figure 2.4 we can see an example of the nodes, the relationships and the attributes.

2.4.3 Data Among Databases

Because of the large amount of information to deal with, it is important to split up them in a way that allow us to handle them in the faster and easiest way, in order to have a good *usability*. Summing up the concepts exploited so far we have the following storing strategy:

- User: stored only on GraphDB
- Recipe: stored on DocumentDB and partially on GraphDB

The reason why we store recipes on both databases is because we want to retrieve social network information from it (likes, suggested recipes based on who added it, and so on). Hence we store on Graph DB a part of the recipe information, and the whole information about recipes on DocumentDB. This partial view of the recipe is the so-called *recipe snapshot*. Generally speaking a snapshot is a partial view of an entity (User or Recipe). When the user clicks on the snapshot then he will see all the information (so for what concerns the recipes, the snapshot is done with GraphDB and the detailed page with DocumentDB).

We can see the storing strategy also in figure 2.5.

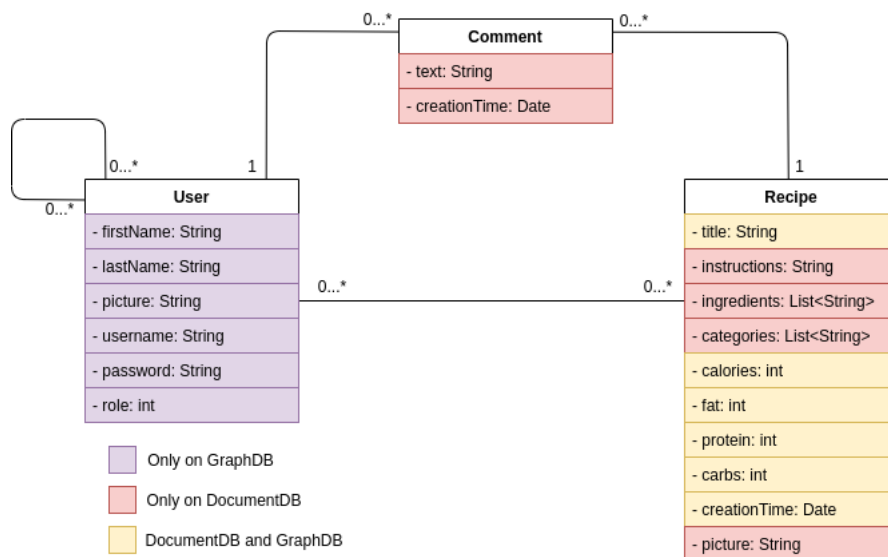


Figure 2.5: Storing Strategy

Another important detail on the Data Model is that we have chosen MongoDB as DBMS for the DocumentDB and Neo4j as DBMS for the GraphDB.

2.5 Distributed Database Design

In our application some of the most important requirements are the *Availability* and the *Consistency*. Thus is very important to us to have a distributed system in order to ensure:

- An high availability of the service, due to the fact that we have more servers (in our case we have 3 virtual machines provided by University of Pisa³) and so we haven't the single point of failure issue.
- An high consistency, because, even if the data on a server would be corrupted (for a server malfunction for instance), we have an update replica that maintains the correct data.

This two objectives can be reached using replicas (copy of the same data on different servers) and sharding (the dataset is split up into different parts, each part is on a different server of the cluster or on more than one server depending from the design choices performed).

The system is on the AC side of the CAP triangle: *Consistency* and *Availability* are ensured by replicas on Neo4J and multi-writes on MongoDB (see following sections).

In the following sections we discuss about these two techniques explaining the design choices performed in order to obtain the best performance achievable and in order to respect the given requirements.

2.5.1 Replicas

We decide to use replicas of the same data in order to ensure *availability* and *consistency*. Nevertheless we have to point out that replicas alone don't ensure consistency, because it's possible to have one or more replicas that are not updated, this doesn't happen in our case because *in order to commit a write operation all replicas must be updated*. This because the application is mainly read-heavy and so we need fast reads operation and, in order to achieve this, we can accept slow write operations. Moreover, this configuration ensures the *Consistency* requirement.

In particular 3 replicas are present in our system: one for each machine of the provided cluster. However in our implementation only for MongoDB we have three replicas, for Neo4J we have only one instance running on server 172.16.3.107: theoretically speaking the Neo4J replicas must be three but it's a premium feature.

So, in order to sum up, let's point out in the following list, the most important points about replicas that must be taken into account.

- 3 replicas for MongoDB, one for each server of the cluster
- 1 instance for Neo4J on 172.16.3.107
- All replicas must be updated in order to commit a write operation

The commands that were used to set the cluster configuration for MongoDB on the virtual machines will now be shown. It was decided to give the lowest priority to the machine running Neo4j (172.16.3.107), for load balancing. The highest priority machine is 172.16.3.157, followed by 172.16.3.108.

```
1  rsconf =
2  {
3      _id: "lsmdb",
4      members:
5      [
6          {
7              _id: 0,
8              host: "172.16.3.157:27020",
9              priority: 2
10         },
11         {
12             _id: 1,
```

³172.16.3.157 - 172.16.3.107 - 172.16.3.108

```

13         host: "172.16.3.107:27020",
14         priority: 0.5
15     },
16     {
17         _id: 2,
18         host: "172.16.3.108:27020",
19         priority: 1
20     }
21 ],
22 settings:
23 {
24     getLastErrorDefaults:
25     {
26         w: 3,
27         wtimeout: 5000
28     }
29 }
30 };

```

As it was expressly requested in the project documentation, a local cluster was also implemented, thanks to which it was possible to test the use of the application even with replicas on Neo4j, in addition of course to those for MongoDB.

2.5.2 Sharding

It's possible to use the following fields as shard key (because they are present in all documents of the collection):

- Object ID (provided by MongoDB)
- Title
- Creation Time
- Instructions
- Ingredients

Using *Instructions* and *Ingredients* has no sense. For what concerns the creation time we search for the most time the most recent recipes, so if we would use it as shard key, we will access always to the shard that contains the last added recipes and the sharding strategy will be unbalanced and so it is useless. At the end we choose the *Object ID* provided by Mongo because it is an automatically generated value which is better than the *Title* that is inserted by the user.

2.6 Software Architecture

In this section the aspects related to the software architecture will be considered, mainly by analyzing the division of tasks between the various modules of the application. The main language used in developing the application is Java.

2.6.1 Client - Server Architecture

The application was implemented as a client-server architecture, with middleware implemented on the client side.

Client Side

The client features can be divided into two modules:

- The front-end module, which consists of a graphical interface based on JavaFX, which allows the users to use the application in the simplest way possible. This is critical to the usability requirement.

- A middleware module, needed to interface the client with the server. More precisely, a driver has been implemented to interface with MongoDB and one to interface with Neo4j.

The application was developed following the MVC (Model, View, Controller) pattern. The View displays the data contained in the model and was mainly developed using .fxml files, which allow you to write all the graphic components and their properties in separate files. The Model provides methods for accessing data useful for the application. The Controller receives the commands from the user and implements them by changing the status of the other two components. This division allowed us to completely separate the three components, for a more readable and maintainable code.

Maven was used to support the implementation of the application.

Server side

The server side, as already mentioned, consists of three virtual machines, on which MongoDB and Neo4J are executed.

2.6.2 Inter-Databases Consistency

Considering how the data was distributed between the two databases, we must consider the problem of consistency on the information that forms the snapshots of the recipes, which are the only information shared by the two databases. The general idea is that if I have to update the data of both databases I have to consider the case where the first update is successful and the second is not (I have to undo the first operation), and the case where the first update is not successful (and therefore I don't even have to do the second). The cases that can lead to these inconsistencies are the following:

- Deleting a recipe
- Adding a recipe
- Update a recipe
- Deleting a user (in this case his recipes must also be deleted)

Chapter 3

Implementation and Test

3.1 Main Modules

The implementation code is divided into two main modules: `RecipeReader` and `JustRecipe`.

- *RecipeReader*: is a program we wrote to get our initial dataset, extracting the information that interests us from the two initial datasets (see chapter 1). To make sense of all the recipes that were initially preloaded, 20 users were entered and the recipes were randomly divided among them. The user's list will be shown in the table 3.1.

Table 3.1: List of initial users

First name	Last name	Username	Password	Role
Oliver	Smith	oliver.smith	oliver.smith	Administrator
Jack	Jones	jack.jones	jack.jones	Moderator
Harry	Williams	harry.williams	harry.williams	User
Jacob	Brown	jacob.brown	jacob.brown	User
Charlie	Taylor	charlie.taylor	charlie.taylor	User
Thomas	Davies	thomas.davies	thomas.davies	User
George	Wilson	george.wilson	george.wilson	User
Oscar	Evans	oscar.evans	oscar.evans	User
James	Thomas	james.thomas	james.thomas	User
William	Roberts	william.roberts	william.roberts	User
Amelia	Murphy	amelia.murphy	amelia.murphy	User
Olivia	Johnson	olivia.johnson	olivia.johnson	User
Isla	Williams	isla.williams	isla.williams	User
Emily	Walsh	emily.walsh	emily.walsh	User
Poppy	Taylor	poppy.taylor	poppy.taylor	User
Ava	Miller	ava.miller	ava.miller	User
Isabella	Byrne	isabella.byrne	isabella.byrne	User
Jessica	Evans	jessica.evans	jessica.evans	User
Lily	Rodriguez	lily.rodriguez	lily.rodriguez	User
Sophie	Roberts	sophie.roberts	sophie.roberts	User

- *JustRecipe*: is the actual application, whose implementation will be analyzed in more details in the next sections.

3.2 Main Packages and Classes

In this section will be presented the main packages of `JustRecipe` module and the respective classes.

3.2.1 it.unipi.dii.inginf.lsd.b.justrecipe.config

This package is used to handle the configuration parameters, stored in *config.xml*. The schema for the validation is in the file *config.xsd*. The validation is very important to be sure of the correctness of the file *config.xml*.

Classes:

- *ConfigurationParameters*: this class stores all the configuration parameters needed by the application. For example the IP for the Neo4j database. These values do not need to be changed, so only get methods are provided.

3.2.2 it.unipi.dii.inginf.lsd.b.justrecipe.main

This package contains the Main class, that starts the application.

Classes:

- *Main*: this class extends *Application* and implements the *start* method.

3.2.3 it.unipi.dii.inginf.lsd.b.justrecipe.model

This package contains the classes required for the model. These classes are the java bean for our application.

Classes:

- *Comment*: This class stores all the information about a comment, like the text, the username of the author and the timestamp of creation.
- *Recipe*: This class stores all the information about a recipe, like the title, the ingredients, and so on.
- *User*: This class stores all the information about a user, like the username, the password, and so on.
- *Session*: This class is used to maintain the information of the session, like the logged user. We used the singleton design pattern for this class.

3.2.4 it.unipi.dii.inginf.lsd.b.justrecipe.persistence

This package deals with managing the persistence of data, in fact it contains the classes used to interface with databases.

Classes:

- *DatabaseDriver*: this *interface* declares all the methods that has to be implemented in a database driver. This methods are *initConnection()* and *closeConnection()*.
- *MongoDBDriver*: this class implements *DatabaseDriver* and is responsible for implementing all the queries that have to be run on MongoDB. We used the Singleton design pattern, because a single instance of this driver must be shared by all application classes.
- *Neo4jDriver*: this class implements *DatabaseDriver* and is responsible for implementing all the queries that have to be run on Neo4j. We used the Singleton design pattern, because a single instance of this driver must be shared by all application classes.

3.2.5 it.unipi.dii.inginf.lsd.b.justrecipe.controller

This package contains the classes required for the controller part of the MVC pattern. For each different page to be shown to the user, a special controller has been implemented, which manages the events resulting from the actions taken by the user and updates the model and the view.

Classes:

- *WelcomePageController*: this class manages the login/register page of the application.

- *HomeController*: this class handles the homepage section of the application (shows the recipes of following users and handles the event, like the click on a recipe snapshot).
- *DiscoveryPageController*: this class manages the discovery section of the application. So it is in charge of showing the results of search made by the user.
- *ProfilePageController*: this class manages the profile section of the application. The profile could be either mine or someone else's. Thanks to this class it is possible to manage some events such as following a user, deleting my profile, seeing his recipes, and so on.
- *AdministrationPageController*: this class handles the Administration section of the application. Of course, not all the users can access to this page, only the moderator (for seeing the last comments) and the administrators (for doing all the possible operations) can access.
- *EditProfilePageController*: this class manages the page for editing the personal profile. The user can insert a new profile image, change the personal information, and so on. The administrator can change the role of the user in this page.
- *AddRecipePageController*: this class manages the page of the application used for insert a new recipe.
- *RecipeSnapshotController*: this class manages the single recipe snapshot, like the click on him.
- *RecipePageController*: this class handles the page in which we show all the information about a recipe. In this page it is possible also to comment a recipe and see the comments already done.
- *CommentController*: this class manages the single comment and all the operations that can be done on him.
- *UserSnapshotController*: this class manages the single snapshot of one user, and all the operations that can be done on him.

3.2.6 it.unipi.dii.inginf.lsdb.justrecipe.utils

This package contains a class used to store all the utility functions that we use in the application. Classes:

- *Utils*: this class is used for containing some utility functions used inside the application (to avoid code replication).

3.3 Constraints

Constraints have been added in the two databases, for the recipe title and for the user's username, which must be unique and always present.

- Constraint on the *title* of the recipe (on MongoDB):

```

1  db.recipes.createIndex (
2    {
3      title:1
4    },
5    {
6      unique: true,
7      name: "title_constraint"
8    }
9  )

```

- Constraint on the *title* of the recipe (on Neo4j):

```

1 CREATE CONSTRAINT title_constraint
2 ON (r:Recipe)
3 ASSERT ( r.title) IS NODE KEY

```

- Constraint on the *username* of the user (on Neo4j):

```

1 CREATE CONSTRAINT username_constraint
2 ON (u:User)
3 ASSERT (u.username) IS NODE KEY

```

As previously mentioned, the Community Edition of Neo4j is used in the cluster on the virtual machines, because the Enterprise version is not free. This implies that on the virtual cluster we cannot define the constraints, and therefore not all functions work correctly, because they are based (as it should be) on the use of constraints.

3.4 Most Relevant Queries

In the following section will be presented the most relevant query performed with MongoDB and Neo4J. Some important point must be underlined:

- The operation of *skip* and *limit*, use in the most of the following queries, are necessary due to implementation reasons. In fact the results are not shown all in the same page (because of the size of the database the output can be huge) but only a subset of the result are shown (for instance, the first X) and in order to go on and see the other result, the query will be performed with different value of *<howManyToSkip>* (the first time is 0, the second is X, the third 2X and so on) and *<howManyToGet>* (it's a fixed number, must be equal to the previous X)
- In Neo4J part, due to performance reasons, some queries compute also followers, followings and recipes added by each user. This is necessary because when the user is given as result this information must be showed and if we don't compute it here we have to do another query for each user.

3.4.1 MongoDB

Search Recipes given a username

This query gives the opportunity to collect all the recipes written by a specific User through checking the author username field. This search is case sensitive cause we are using the username.

- Input: a string who represent an username (unique through the users), how many recipe to skip, and how many to get.
- Output: a list of recipes, all added by the user erlier selected, ordered by the .

```

1 db.recipes.aggregate (
2   [
3     {
4       $match :
5       {
6         authorUsername : <authorUsername>
7       }
8     },
9     {
10      $sort :
11      {
12        creationTime : -1
13      }

```

```

14     },
15     {
16         $skip: <howManyToSkip>
17     },
18     {
19         $limit: <howManyToGet>
20     }
21 ]
22 )

```

Search for recipe title

Given a portion of the title, this query is capable of returning as a result a set of recipes whose titles contain it. Research must be case insensitive (see *options:"i"* in the match step of the aggregation)

- Input: portion of the title, how many recipes to skip and how many recipes to get.
- Output: set of recipes.

```

1 db.recipes.aggregate (
2   [
3     {
4       $match :
5       {
6         title:
7         {
8           $regex: /^.*<portionOfTheTitle>.*$/,
9           $options: "i"
10        }
11      }
12    },
13    {
14      $sort :
15      {
16        creationTime : -1
17      }
18    },
19    {
20      $skip: <howManyToSkip>
21    },
22    {
23      $limit: <howManyToGet>
24    }
25  ]
26 )

```

Get the username of the most versatile user

This query let select the most versatile user, the one who had covered more recipe categories (if he/she added at least 5 different recipe in a *category*, than this *category* is covered).

The users are sorted by the number of distinct categories. If users have the same number of distinct categories the lexicographic order is taken into account.

- Input: *no input*
- Output: For this early implementation of this application, we need only the best most versatile user (the first one, his/her username)

```

1 db.recipes.aggregate
2 (
3   [
4     {
5       $unwind : "$categories"
6     },
7     {
8       $group :
9       {
10        _id:
11        {
12          "author": "$authorUsername",
13          "category": "$categories"
14        },
15        numRecipe:
16        {
17          $sum: 1
18        }
19      }
20    },
21    {
22      $match:
23      {
24        numRecipe:
25        {
26          $gte: 5
27        }
28      }
29    },
30    {
31      $group :
32      {
33        _id : "$_id.author",
34        distinctCategories:
35        {
36          $sum: 1
37        }
38      }
39    },
40    {
41      $project:
42      {
43        'username': '$_id',
44        distinctCategories: 1,
45        _id: 0
46      }
47    },
48    {
49      $sort :
50      {
51        distinctCategories: -1,
52        username: 1
53      }
54    },
55    {
56      $limit: 1
57    }
58  ]

```

```
59 ]
60 )
```

Search for recipe category

Given the category, or a part of this, the query returns recipes that belong to it. The search is case insensitive.

It's important to point out that a recipe belongs to more than one categories, so a recipe can be part of the result of the search of two different categories (this is normal and it is allowed).

- Input: portion of the category or the entire one *<portionOfTheCategory>*, how many recipes to skip *<howManyToSkip>* and how many to get *<howManyToGet>*.
- Output: set of recipes belonging to the given category

```
1 db.recipes.aggregate (
2   [
3     {
4       $match :
5       {
6         categories:
7         {
8           $regex: /^.*<portionOfTheCategory>.*$/,
9           $options: "i"
10        }
11      }
12    },
13    {
14      $sort :
15      {
16        creationTime : -1
17      }
18    },
19    {
20      $skip: <howManyToSkip>
21    },
22    {
23      $limit: <howManyToGet>
24    }
25  ]
26 )
```

Search for recipe ingredients

This query give the possibility to find a specific number of recipes given some of the recipe ingredients (or a portion of them). The search is case insensitive for a more easy to use experience.

- Input: a list of ingredients, how many recipes to skip and how many recipe to show.
- Output: a list of recipes, all of them have at least all the ingredients specified before. The results are ordered from the newer to the older recipe.

It is important to say that there will be a *match* step for each ingredients specified by the user.

```
1 db.recipes.aggregate (
2   [
3     {
4       $match :
```



```

5     {
6       ingredients:
7       {
8         $regex: /\.*<ingredients[i]>.*$/,
9         $options: "i"
10      }
11    }
12  },
13  {
14    $sort :
15    {
16      creationTime : -1
17    }
18  },
19  {
20    $skip: <howManyToSkip>
21  },
22  {
23    $limit: <howManyToGet>
24  }
25 ]
26 )

```

Most common recipe categories

This query allows you to get a ranking of the categories most used by users for their recipes.

- Input: how many categories to skip, how many categories to get.
- Output: list with the categories ordered by the number of use.

```

1 db.recipes.aggregate (
2   [
3     {
4       $unwind : "$categories"
5     },
6     {
7       $group :
8       {
9         _id : "$categories",
10        numberOfRecipes:
11        {
12          $sum: 1
13        }
14      }
15    },
16    {
17      $project:
18      {
19        'category': '$_id',
20        numberOfRecipes: 1,
21        _id: 0
22      }
23    },
24    {
25      $sort :
26      {
27        numberOfRecipes : -1
28      }

```

```

29     },
30     {
31         $skip: <howManyToSkip>
32     },
33     {
34         $limit: <howManyToGet>
35     }
36 ]
37 )

```

Last Comments

The query returns the last comments sorted for creation time, in order to have the most recent as first and the most old as last.

- Input: *howManyToGet* and *howManyToSkip*
- Output: set of the last comments sorted by creation time in descendant order.

```

1 db.recipes.aggregate (
2   [
3     {
4       $unwind : "$comments"
5     },
6     {
7       $sort :
8       {
9         "comments.creationTime" : -1
10      }
11    },
12    {
13      $skip: <howManyToSkip>
14    },
15    {
16      $limit: <howManyToGet>
17    }
18  ]
19 )

```

Weekly Recipes per User

A query who returns all the recipes between two dates, first day of the week and first day of the next week.

- Input: *Username* who represent the user.
- Output: set of recipes which the user has added in the current week.

```

1 db.recipes.aggregate {
2   $match:
3   {
4     $and:
5     [
6       {
7         creationTime
8         {
9           $gte: <firstDateOfWeek>,
10          $lt: <firstDateOfNextWeek>

```

```
11         }
12     },
13     {
14         authorUsername: <username>
15     }
16 ]
17 }
18 }
```

3.4.2 Neo4J

Now we will talk about the queries on Neo4j, but first we need to consider their domain-specific to graph-centric translation in the table 3.2

Table 3.2: Graph-Centric Query and Domain-Specific Query

Graph-Centric Query	Domain-Specific Query
How many incoming edges are incident to vertex A?	How many users follow one user? How many likes has a recipe received?
How many hops does it take to get from vertex A to vertex B?	How many follows relations are between User A and User B? (used within the search for suggested recipes)
What is the centrality measure of vertex B? (How well connected is?)	Most followed and active users, Best recipes, Most liked users

A partial example of a graph (screenshot made during the execution of the program) is shown in the figure 3.1, in order to have more clear the concepts that will be expressed later in the implementation of the queries.



Figure 3.1: Partial example of the graph in Neo4j

Suggested Recipes

We have two levels of suggestions with different relevance.

- First Level

Recipe R is a first level suggestion for the user X , if R has been added by the user Y where Y is followed by W who is followed by X ($X \rightarrow W \rightarrow Y$). Or R has been added by Z where Z is followed by Y ($X \rightarrow W \rightarrow Y \rightarrow Z$).

- Second Level

Recipe R is a second level suggestion for the user X if R has been added by the user Y where Y is the owner of at least N recipes liked by X .

The two level of suggestions are in a single query, the first recipes are the ones related to the first level, then at the end we have the ones related to the second level. The code is show below:

```

1  MATCH path =
2  (recipe:Recipe)<-[a:ADDS]-(owner:User)<-[:FOLLOWS*2..3]
3  -(me:User{username:$u})
4  WHERE owner.username <> $u
5  RETURN recipe.title, recipe.calories, recipe.carbs,
6  recipe.protein, recipe.fat, recipe.picture,
7  a.when, owner.username
8  ORDER BY length(path) ASC, a.when DESC
9  SKIP $howManyToSkipFirstLv
10 LIMIT $howManyToGetFirstLv
11 UNION
12 MATCH (:User{username:$u})-[l:LIKES]->(:Recipe)<-[:ADDS]-(
13  owner:User)
14 WITH DISTINCT(owner) AS owner, COUNT(DISTINCT l) AS numLikes
15 WHERE numLikes > $threshold AND owner.username <> $u
16 MATCH (owner)-[a:ADDS]->(recipe:Recipe)
17 RETURN recipe.title, recipe.calories, recipe.carbs,
18 recipe.protein, recipe.fat, recipe.picture, a.when,
19 owner.username
20 ORDER BY a.when DESC
21 SKIP $howManyToSkipSecondLv
22 LIMIT $howManyToGetSecondLv

```

Recipes of following users

This query returns all the recipes of the following users of a specific user.

- Input: How many recipe name to skip, how many recipe name to show and a string who represents a specific username.
- Output: A set of recipe name of the specific user's following users have added.

```

1  MATCH (u1:User{username:$username})-[:FOLLOWS]->(u2:User)-[a:
2  ADDS]->(r:Recipe)
3  RETURN r.title AS title, r.calories AS calories,
4  r.fat AS fat, r.protein AS protein, r.carbs AS carbs,
5  r.picture AS picture, u2.username AS authorUsername
6  ORDER BY a.when DESC
7  SKIP $skip LIMIT $limit

```

Most followed and active users

This query returns the list of the most followed and active users, namely the influencers. Most followed means that the list is ordered by the number of followers. Active means that the list is ordered by the number of recipes added by the user.

- Input: How many users to skip, how many users to show.
- Output: A list of the most followed and active users.

```

1 MATCH (u:User)
2 OPTIONAL MATCH (u)-[f1:FOLLOWS]-(:User)
3 OPTIONAL MATCH (u)-[f2:FOLLOWS]->(:User)
4 OPTIONAL MATCH (u)-[a:ADDS]->(:Recipe)
5 RETURN u.firstName, u.lastName, u.username,
6        u.firstName AS firstName, u.lastName AS lastName,
7        u.picture AS picture, u.username AS username,
8        u.password AS password, u.role AS role,
9        COUNT(DISTINCT f1) AS follower,
10       COUNT(DISTINCT f2) AS following,
11       COUNT(DISTINCT a) AS numRecipes
12 ORDER BY follower DESC, numRecipes DESC
13 SKIP $howManySkip LIMIT $howMany

```

Most liked users

This query returns the list of the most liked users, namely the users who received more like to their recipes.

- Input: How many users to skip, how many users to show.
- Output: A list of the most liked users.

```

1 MATCH (u:User)
2 OPTIONAL MATCH (u)-[:ADDS]->(:Recipe)-[l:LIKES]-(:User)
3 OPTIONAL MATCH (u)-[f1:FOLLOWS]-(:User)
4 OPTIONAL MATCH (u)-[f2:FOLLOWS]->(:User)
5 OPTIONAL MATCH (u)-[a:ADDS]->(:Recipe)
6 RETURN u.firstName, u.lastName, u.username,
7        u.firstName AS firstName, u.lastName AS lastName,
8        u.picture AS picture, u.username AS username,
9        u.password AS password, u.role AS role,
10       COUNT(DISTINCT f1) AS follower,
11       COUNT(DISTINCT f2) AS following,
12       COUNT(DISTINCT a) AS numRecipes,
13       COUNT(DISTINCT l) AS totLikes
14 ORDER BY totLikes DESC
15 SKIP $howManySkip LIMIT $howMany

```

Best Recipes

This query returns the list of the best recipes, namely the most liked ones.

- Input: How many recipes to skip, how many recipes to show.
- Output: A list of the best recipes.

```

1 MATCH (:User)-[l:LIKES]->(r:Recipe)
2 MATCH (u:User)-[a:ADDS]->(r)
3 RETURN r.title AS title, r.calories AS calories,
4        r.fat AS fat, r.protein AS protein, r.carbs AS carbs,
5        r.picture AS picture, u.username AS authorUsername,
6        COUNT(DISTINCT l) AS likes
7 ORDER BY likes DESC
8 SKIP $skip LIMIT $limit

```

To clarify, the first match is used to avoid to consider the recipes which have not at least one like, and the second match is used to find the user that adds the recipe.

Search for username

Given a portion of the username, this query is able to return all users whose usernames contain it. The search must be case insensitive, so the `toLower` function is used.

- Input: portion of the username, how many users to skip and how many users to get.
- Output: set of users.

```
1 MATCH (u:User)
2 WHERE toLower(u.username) CONTAINS toLower($username)
3 OPTIONAL MATCH (u)<-[f1:FOLLOWS]-(:User)
4 OPTIONAL MATCH (u)-[f2:FOLLOWS]->(:User)
5 OPTIONAL MATCH (u)-[a:ADDS]->(:Recipe)
6 RETURN u.firstName AS firstName, u.lastName AS lastName,
7        u.picture AS picture, u.username AS username,
8        u.password AS password, u.role AS role,
9        COUNT(DISTINCT f1) AS follower,
10       COUNT(DISTINCT f2) AS following,
11       COUNT(DISTINCT a) AS numRecipes
12 SKIP $skip LIMIT $limit
```

Search for user's full-name

Given the full-name or a part of it, the query returns the users that contains in their full-name the given input. The query is case-insensitive.

- Input: The full-name (*\$fullName*), how many users to skip (*\$skip*) and how many users to get (*\$limit*).
- Output: The users that contains in their full-name the given input *\$fullName*.

```
1 MATCH (u:User)
2 WHERE
3   toLower(u.firstName+' '+u.lastName)
4   CONTAINS toLower($fullName)
5   OR
6   toLower(u.lastName + ' ' + u.firstName)
7   CONTAINS toLower($fullName)
8   OPTIONAL MATCH (u)<-[f1:FOLLOWS]-(:User)
9   OPTIONAL MATCH (u)-[f2:FOLLOWS]->(:User)
10  OPTIONAL MATCH (u)-[a:ADDS]->(:Recipe)
11  RETURN u.firstName AS firstName, u.lastName AS lastName,
12         u.picture AS picture, u.username AS username,
13         u.password AS password, u.role AS role,
14         COUNT (DISTINCT f1) AS follower,
15         COUNT (DISTINCT f2) AS following,
16         COUNT (DISTINCT a) AS numRecipes
17  SKIP $skip LIMIT $limit
```

3.5 Some snapshots of code

Some interesting snapshots of the code will be showed.

3.5.1 Most relevant queries

The implementation code in Java language of the most interesting queries among those seen in the previous section will also be shown.

Get the username of the most versatile user

```
1 public String searchMostVersatileUser(final int recipesThreshold)
2 {
3     Bson unwind = unwind("$categories");
4     Bson group = new Document("$group",
5         new Document("_id",
6             new Document("author", "$authorUsername")
7                 .append("category", "$categories")
8                 .append("numRecipe", new Document("$sum", 1)));
9     Bson match = match(gte("numRecipe", recipesThreshold));
10    Bson group2 = group("$_id.author", sum("distinctCategories", 1));
11    Bson project = project(fields(computed("username", "$_id"),
12        excludeId(), include("distinctCategories")));
13    Bson sortNumName = new Document("$sort", new Document("distinctCategories",
14        -1).append("username", 1));
15    Bson limit = limit(1);
16
17    Document doc = (Document) collection.aggregate(
18        Arrays.asList(unwind, group, match, group2, project,
19            sortNumName, limit)).first();
20
21    return doc.getString("username");
22 }
```

Most common recipe categories

```
1 public List<String> searchMostCommonRecipeCategories (final int howManySkip,
2     final int howManyCategories)
3 {
4     List<String> mostCommonCategories = new ArrayList<>();
5     Bson unwind = unwind("$categories");
6     Bson group = group("$categories", Accumulators.sum("numberOfRecipes", 1));
7     Bson project = project(fields(computed("category", "$_id"),
8         excludeId(), include("numberOfRecipes")));
9     Bson sort = sort(descending("numberOfRecipes"));
10    Bson skip = skip(howManySkip);
11    Bson limit = limit(howManyCategories);
12    List<Document> results = (List<Document>) collection.aggregate(
13        Arrays.asList(unwind, group, project, sort, skip, limit))
14        .into(new ArrayList());
15
16    for (Document document: results)
17    {
18        mostCommonCategories.add(document.getString("category"));
19    }
20    return mostCommonCategories;
21 }
```

Last comments

```
1 public List<List<Object>> searchAllComments (final int howManySkip, final int
2     howMany)
3 {
4     List<List<Object>> objects = new ArrayList<>();
5     Gson gson = new Gson();
6     Bson unwind = unwind("$comments");
7     Bson sort = sort(descending("comments.creationTime"));
8     Bson skip = skip(howManySkip);
9     Bson limit = limit(howMany);
10    MongoCursor<Document> iterator = (MongoCursor<Document>)
11        collection.aggregate(Arrays.asList(unwind, sort, skip, limit)).iterator();
12    while (iterator.hasNext())
13    {
14        Document document = iterator.next();
15        Document commentDocument = (Document) document.get("comments");
16        Comment comment = gson.fromJson(gson.toJson(commentDocument), Comment.class);
17        // I need to re-obtain the full recipe
18        Recipe recipe = getRecipeFromTitle(document.getString("title"));
19    }
```



```

18
19     List<Object> objectList = new ArrayList<>();
20     objectList.add(comment);
21     objectList.add(recipe);
22
23     objects.add(objectList);
24 }
25 return objects;
26 }

```

Suggested recipes

```

1 public List<Recipe> getSuggestedRecipes(final String username, final int
    threshold, final int howManyToSkipFirstLv, final int howManyToGetFirstLv,
    final int howManyToSkipSecondLv, final int howManyToGetSecondLv)
2 {
3     List<Recipe> recipes = new ArrayList<>();
4     try(Session session = driver.session())
5     {
6         recipes = session.readTransaction((TransactionWork<List<Recipe>>) tx ->
7         {
8             Result result = tx.run("
9             MATCH path = (recipe:Recipe)<-[a:ADDS]-
10              (owner:User)<-[FOLLOWS*2..3]-(me:User{username:$u})
11             WHERE owner.username <> $u
12             RETURN recipe.title, recipe.calories, recipe.carbs, recipe.protein,
13                recipe.fat, recipe.picture, a.when, owner.username
14             ORDER BY length(path) ASC, a.when DESC
15             SKIP $firstLvSkip LIMIT $firstLvGet
16             UNION
17             MATCH (:User {username: $u})-[l:LIKES]->(:Recipe)
18              <-[a:ADDS]-(owner:User)
19             WHERE owner.username <> $u
20             WITH DISTINCT(owner) AS owner, COUNT(DISTINCT l) AS numLikes
21             WHERE numLikes > $threshold AND owner.username <> $u
22             MATCH (owner)-[a:ADDS]->(recipe:Recipe)
23             RETURN recipe.title, recipe.calories, recipe.carbs, recipe.protein,
24                recipe.fat, recipe.picture, a.when, owner.username
25             ORDER BY a.when DESC
26             SKIP $secondLvSkip LIMIT $secondLvGet",
27                parameters("u", username, "firstLvSkip", howManyToSkipFirstLv,
28                "firstLvGet", howManyToGetFirstLv, "threshold", threshold,
29                "secondLvSkip", howManyToSkipSecondLv,
30                "secondLvGet", howManyToGetSecondLv));
31
32         List<Recipe> r = new ArrayList<>();
33
34         while(result.hasNext())
35         {
36             Record rec = result.next();
37             String title = rec.get("recipe.title").asString();
38             int calories = 0;
39             int protein = 0;
40             int fat = 0;
41             int carbs = 0;
42             String picture = null;
43             String authorUsername = rec.get("owner.username").asString();
44             if(rec.get("recipe.calories") != NULL)
45                 calories = rec.get("recipe.calories").asInt();
46             if(rec.get("recipe.fat") != NULL)
47                 fat = rec.get("recipe.fat").asInt();
48             if(rec.get("recipe.protein") != NULL)
49                 protein = rec.get("recipe.protein").asInt();
50             if(rec.get("recipe.carbs") != NULL)
51                 carbs = rec.get("recipe.carbs").asInt();
52             if(rec.get("recipe.picture") != NULL)
53                 picture = rec.get("recipe.picture").asString();
54             Recipe recipe = new Recipe(title, fat, calories, protein, carbs,
55                picture);
56             recipe.setAuthorUsername(authorUsername);
57             r.add(recipe);
58         }

```

```

59         return r;
60     });
61 }
62 return recipes;
63 }

```

Most followed and active users

```

1 public List<User> searchMostFollowedAndActiveUsers (final int howManySkip,
2     final int howMany)
3 {
4     List<User> users = new ArrayList<>();
5     try (Session session = driver.session())
6     {
7         users = session.readTransaction((TransactionWork<List<User>>) tx ->
8         {
9             Result result = tx.run("
10             MATCH (u:User)
11             OPTIONAL MATCH (u)<-[f1:FOLLOWS]-(:User)
12             OPTIONAL MATCH (u)-[f2:FOLLOWS]->(:User)
13             OPTIONAL MATCH (u)-[a:ADDS]->(:Recipe)
14             RETURN u.firstName, u.lastName, u.username, u.firstName AS firstName,
15                 u.lastName AS lastName, u.picture AS picture, u.username AS username,
16                 u.password AS password, u.role AS role,
17                 COUNT(DISTINCT f1) AS follower,
18                 COUNT(DISTINCT f2) AS following,
19                 COUNT(DISTINCT a) AS numRecipes
20             ORDER BY follower DESC, numRecipes DESC
21             SKIP $howManySkip LIMIT $howMany",
22                 parameters("howManySkip", howManySkip, "howMany", howMany));
23             List<User> listOfUsers = new ArrayList<>();
24             while (result.hasNext())
25             {
26                 Record r = result.next();
27                 String firstName = r.get("firstName").asString();
28                 String lastName = r.get("lastName").asString();
29                 String picture = null;
30                 if (r.get("picture") != NULL)
31                 {
32                     picture = r.get("picture").asString();
33                 }
34                 String username = r.get("username").asString();
35                 String password = r.get("password").asString();
36                 int role = r.get("role").asInt();
37                 User user = new User(firstName, lastName, picture, username,
38                     password, role);
39                 user.setFollower(r.get("follower").asInt());
40                 user.setFollowing(r.get("following").asInt());
41                 user.setNumRecipes(r.get("numRecipes").asInt());
42                 listOfUsers.add(user);
43             }
44             return listOfUsers;
45         });
46     }
47     return users;
48 }

```

3.6 Tests and Statistical Analysis

3.6.1 Queries Analysis

The most queries consist in read operations and so we can say that the application is read-heavy. In the table 3.3 we can see the frequency of each query.

Table 3.3: Queries Frequency

Query	Frequency
Search Recipes given a username	High
Search for Recipe Title	Medium
Get the username of the most versatile user	Low
Search for Recipe Category	Low
Search for Recipe Ingredients	Low
Most Common Recipe Categories	Low
Last Comments	Medium
Weekly Recipes per User	High
Suggested Recipes	High
Recipes of Following Users	High
Most Followed an Active Users	Low
Most Liked Users	Low
Best Recipes	Low
Search for Username	Medium
Search for User's Full Name	Low

3.6.2 Index Analysis

In this subsection the indices for both MongoDB and Neo4J will be considered, and statistical tests will be performed to understand their benefit. For each index will be considered the queries that are in some way affected by its presence. For performance measures of Neo4j queries, the keyword *PROFILE* was used at the beginning of the query, which allows you to see the steps behind the execution of the query. We have to underline that in using *PROFILE* we have to neglect the first value of execution time, because this is affected by the time that Neo4J spends in executing the statistical information and the graphical output given by the command, from the second execution the time execution is reliable (the most of the previous information are already computed). For MongoDB, we used the *explain()*.

The following index will be analyzed:

- Recipe Title (MongoDB and Neo4j)
- User Username (Neo4J)
- Recipe Creation Time (MongoDB)
- Comment Creation Time (MongoDB)
- Text index on recipe ingredients (MongoDB)

Index on Recipe Title

Since a constraint on the recipe title was needed, and this was implemented with an index on it, then the index on the recipe title was not taken into account in these tests, because it is mandatory.

Index on User Username

The constraint on the username is also inserted through an index, so the index on the username is also mandatory.

Index on Recipe Creation Time

A study of performance has been completed, the results are available in table 3.4. The table displays that the index on the creation time field is a good index, which improve the performance of the application, by reducing the number of document and keys examined and reducing the execution time, for all the query considered. All the following query has been tried as they could appear during the natural execution of the application. All of this query are sorted by the creation time (descending) but the first one, this consider the recipes added by a user in a date interval. This results are so good that the index tested has been implemented on MongoDB.

Table 3.4: Test on creationTime Index

Query	Results without Index	Results with Index
Weekly Recipes per User	executionTimeMillis : 30, totalKeysExamined : 0, totalDocsExamined : 45348	executionTimeMillis : 2, totalKeysExamined : 0, totalDocsExamined : 0
Search Recipes given a username	executionTimeMillis : 37, totalKeysExamined : 0, totalDocsExamined : 45348	executionTimeMillis : 7, totalKeysExamined : 1280, totalDocsExamined : 1280
Search for Recipe Title	executionTimeMillis : 57, totalKeysExamined : 45348, totalDocsExamined : 389	executionTimeMillis : 29, totalKeysExamined : 6126, totalDocsExamined : 6126
Search for recipe category	executionTimeMillis : 75, totalKeysExamined : 0, totalDocsExamined : 45348	executionTimeMillis : 2, totalKeysExamined : 129, totalDocsExamined : 129
Search for recipe ingredients	executionTimeMillis : 226, totalKeysExamined : 0, totalDocsExamined : 45348	executionTimeMillis : 32, totalKeysExamined : 4591, totalDocsExamined : 4591

```
1 db.recipes.createIndex({creationTime:-1},{name:'creationTime_index'})
```

Index on Comment Creation Time

A possible index is the one on the creation time of the comment, this index affects the query *Last Comments*. In order to see if the index must be added or not, let analyze the result of the index analysis for this index on that query (see table 3.5)

Table 3.5: Statistics about comment creation time index

Query	Results without index	Results with index
Last Comments	ExecutionTimeMillis: 123ms TotalKeysExamined: 0 TotalDocsExamined: 45348	ExecutionTimeMillis: 2ms TotalKeysExamined: 18 TotalDocsExamined: 3

From the result obtained we can see that the addition of that index imply an improvement in the performance. In fact the query with the index requires less time with respect to the one without index.

For this reason we create an index on the creation time of the comment.

The reason for the improvement of the performance is because we create a sparse index, so the recipes in which there aren't comments are not taken into account. Thus if the index is present it examines a number of keys that is lesser than the number of recipes, because not all recipes contain comments. In the test scenario are present 18 comments in 3 different recipes and in fact only these are taken into account with a huge reduction of examined docs.

```
1 db.recipes.createIndex({"comments.creationTime":-1},  
2 {sparse:true, name:'commentsCreationTime_index'})
```

Index on Ingredients

A possible *text index* is the one on the ingredients due to the fact that we have to search them. In order to test the text index we use the following query as example.

```
1 db.recipes.explain("executionStats").aggregate([
2   {$match: {"$text": {"$search": "\"vanilla\" \"milk\" \"strawberries\""} }},
3   {$sort: {creationTime: -1}},
4   {$skip: 0}, {$limit: 20}
5 ])
```

The results are the ones in the table 3.6.

Table 3.6: Statistics about comment creation time index

Query	Results without index	Results with index
Search For Recipe's Ingredients	ExecutionTimeMillis: 91ms	ExecutionTimeMillis: 249ms
	TotalKeysExamined: 6514	TotalKeysExamined: 12239
	TotalDocsExamined: 6514	TotalDocsExamined: 998

Considering the results we can notice that without index the system uses the index on the creation time and for our queries that index is the one that ensures better performance.

Chapter 4

User Manual

In this chapter we discuss how to use the application from the user's point of view.

4.1 How To Configure The System

In order to configure the application an XML file is provided, this file contains configuration parameters that can affect the proper work of the application so only in particular cases must be changed. In any case the XML file will be validated and the application doesn't work if this validation fails. The file contains the following code.

```
1  <?xml version="1.0" encoding="UTF-8"?>
2  <it.unipi.dii.inginf.lsdب.justrecipe.config.ConfigurationParameters>
3    <mongoFirstIp>172.16.3.157</mongoFirstIp>
4    <mongoFirstPort>27020</mongoFirstPort>
5    <mongoSecondIp>172.16.3.107</mongoSecondIp>
6    <mongoSecondPort>27020</mongoSecondPort>
7    <mongoThirdIp>172.16.3.108</mongoThirdIp>
8    <mongoThirdPort>27020</mongoThirdPort>
9    <mongoUsername></mongoUsername>
10   <mongoPassword></mongoPassword>
11   <mongoDbName>justrecipe</mongoDbName>
12   <neo4jIp>172.16.3.107</neo4jIp>
13   <neo4jPort>7687</neo4jPort>
14   <neo4jUsername>neo4j</neo4jUsername>
15   <neo4jPassword>justrecipe</neo4jPassword>
16 </it.unipi.dii.inginf.lsdب.justrecipe.config.ConfigurationParameters>
```

4.2 Login And Registration

At the first launch of the application the window in figure 4.1 is shown:

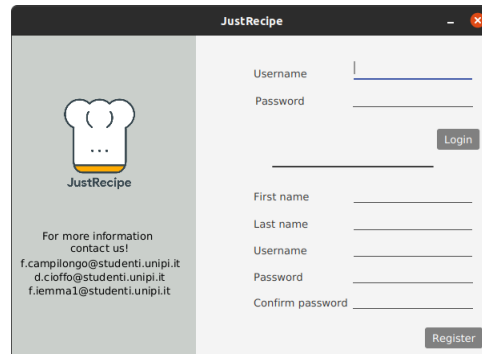


Figure 4.1: First window of the application

Now the user has two possibilities:

- if he is already registered he can do the login
- if he is not registered yet, then he must sign-up to use the application.

Let suppose that we are in the second case. So we have to compile the sign-up section as it is shown in the figure 4.2. Where we register the user *Albert Einstein* with username *a.einstein* and password *a.einstein*.

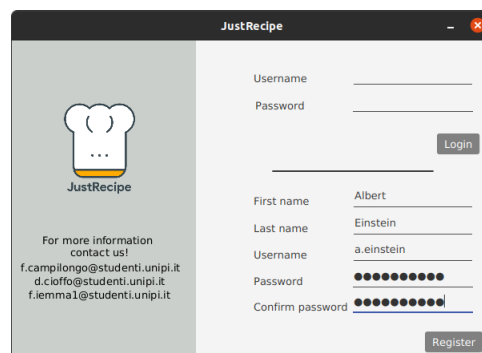


Figure 4.2: Sign-up section

If the user click on **Register** the user will be registered and the login will be performed automatically.

If the user is already registered then he can directly sign-in using the login section as in figure 4.3.

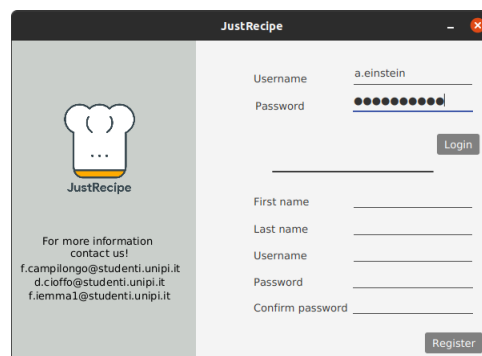


Figure 4.3: Login section

4.3 Homepage, Discovery and First Steps

Let continue with the user *a.einstein*. After the login the homepage will be shown. In the homepage there are the recipes of the following users, due to the fact that the logged user is a new user, he doesn't follow anyone and so he sees nothing (see figure 4.4).

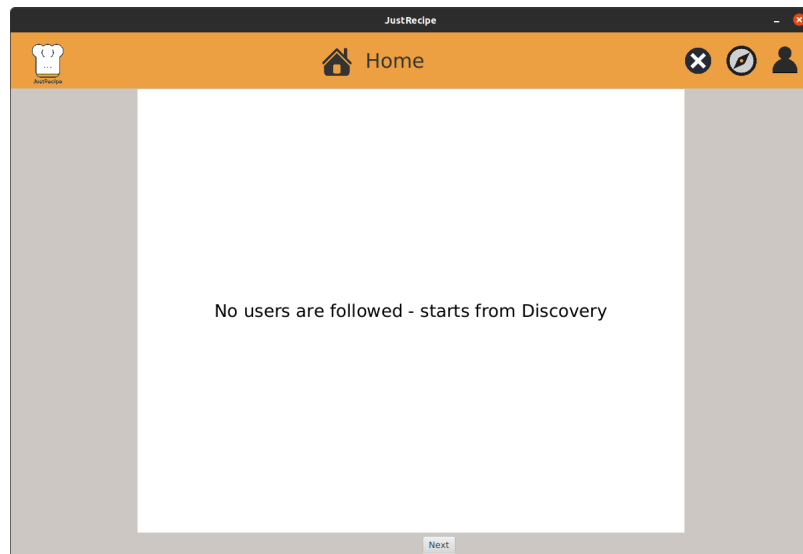


Figure 4.4: Initial page

In order to follow other users and starts to read recipes, the user must click on the icon that represents the **Discovery** page, as shown in figure 4.5.



Figure 4.5: Discovery Icon

After the click on this icon the discovery page will be showed. In this page it's possible to do a lot of searches. As default one the user will see their suggested recipes computed considering his relationships with others users of the social. If the user is a new one his suggested recipes will be the best ones, as we can see in figure 4.6.

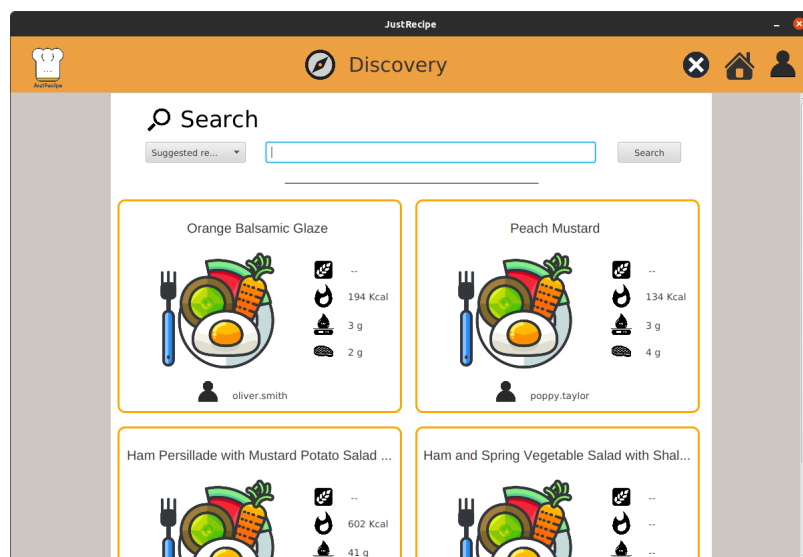


Figure 4.6: Discovery Page First Access

If the user wants to see the detail of a recipe he can click on its snapshot, where the snapshot is the one showed in figure 4.7.

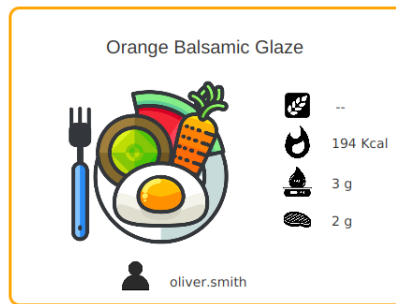


Figure 4.7: Example of a snapshot

If he clicks on the snapshot the recipe page will be showed, as we can see in figure 4.8.

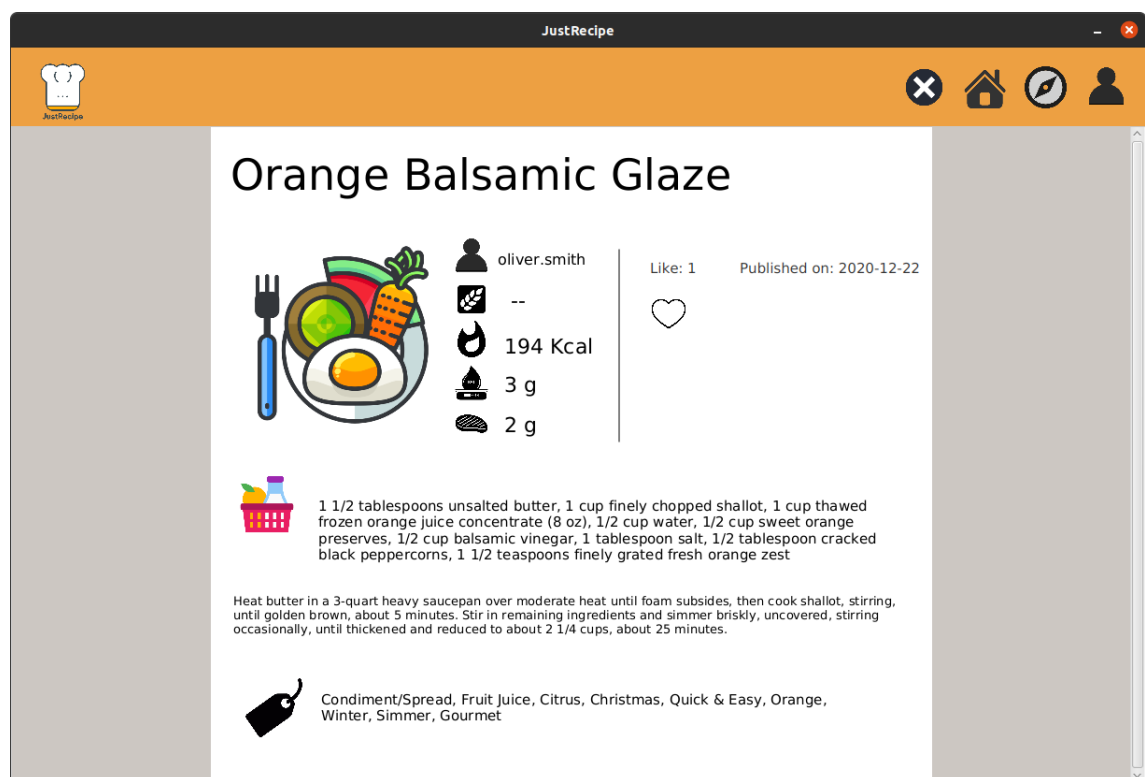


Figure 4.8: Recipe page

There, near the recipe image, it's possible to see in order: the username of who has added the recipe, carbs, calories, fat, protein. In the right part it's possible to see: how many likes the recipe has, when it was added and the icon that allow us to like the recipe. If the user clicks on the heart-like icon, he likes the recipe and the icon will be colored in red, in order to show that the logged user has liked this recipe. We can see it in figure 4.9 and 4.10.



Figure 4.9: Before Like

Like: 2 Published on: 2020-12-22



Figure 4.10: After Like

Another possibility is that the user can follow the user that has added this recipes, in order to do this he must access to his profile page, so he has to click on the user icon or on the user's name as is shown in figure 4.11.

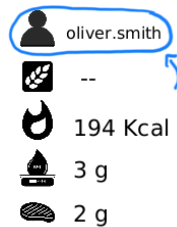


Figure 4.11: User Icon

Then the user page will be shown as we can see in figure 4.12.



Figure 4.12: User Page

If the user wants to follow this user he can click on the correspondent icon near the name of the user as it is shown in figure 4.13. After the click the icon changes in order to notify that the logged user has started to follow this user.



Figure 4.13: Before Follow



Figure 4.14: After follow

Now if the user goes back to the homepage he will see the recipes added by *oliver.smith* because he follows him. So he can click on the home-like icon and go to the homepage as it is shown in the figure 4.15 and 4.16.

Only the first 10 recipes are shown, so if he scrolls until the end he can click on the button **Next** to see the next 10, and then the button **Previous** to see the previous 10. We can see this in figure 4.16 and 4.17.



Figure 4.15: Homepage Icon

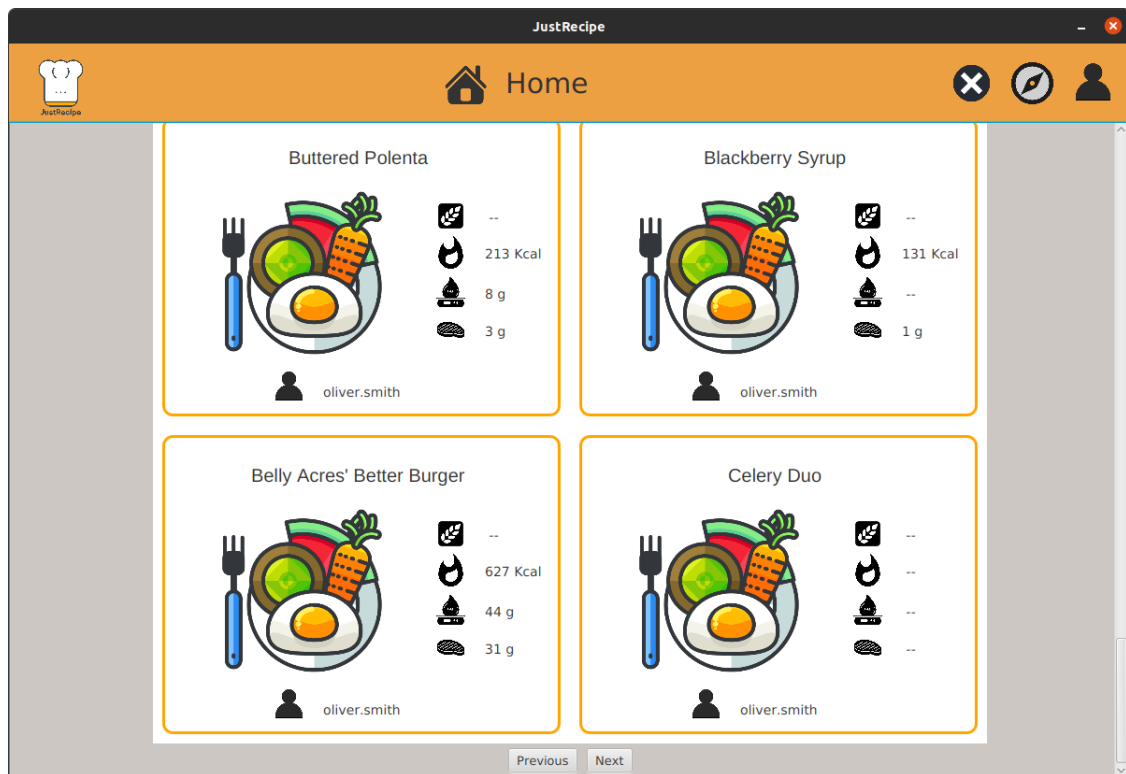


Figure 4.16: Previous and Next Buttons in homepage

The figure 4.16 shown **Next** and **Previous** in the homepage but they are present in all the pages that allow to scroll recipes and/or users.

4.4 User Profile

If the user wants to visualize his profile he must click on the proper icon on the menu as we can see in the figure 4.17.



Figure 4.17: Profile Icon

Now the user can see his profile image. On the top-left he can see his profile image, his username and two icons. The first one starting from the left is for deleting the account and the second one is for modifying the account. Then on the center-left-side there are information about the followers, the following users and the recipes added. On the right-side there are four icons that in order allow to add a recipe, to go to the discovery page, to go to the homepage, to logout. At the top of the page there is a plot in which are plotted the recipes added in the last week. In the center of the page there are the added recipes (now there are no ones because we don't add any recipes).

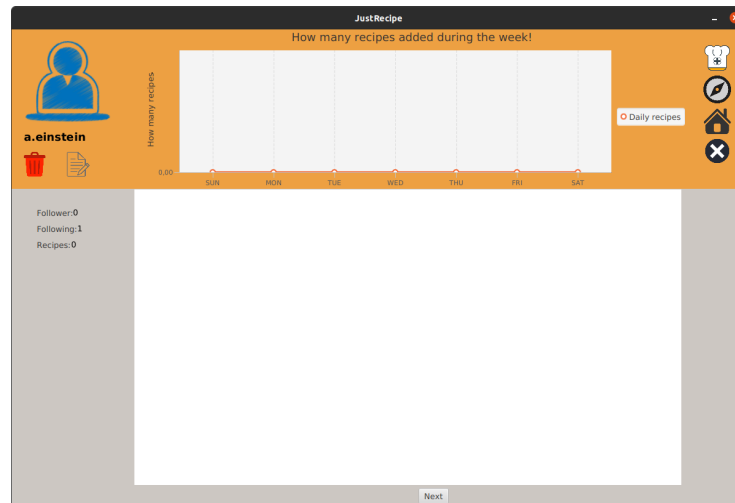


Figure 4.18: Logged User Profile

So let add a recipe, in order to do this the user must click on the correspondent button as we said previously. Then the page in figure 4.19 will be shown.

Figure 4.19: Add Recipe Page

So the user must compile the fields and then click on **Submit** to add the recipe. The following fields are mandatory:

- Title
- Instructions
- Ingredients

The button **Clear** allow to clear, in a fast way, the fields if the user puts some wrong information. At the end, if the operation is successfully performed a successfully message will be shown and if the user goes on his profile, then the new recipe is there as we can see in the figure 4.20.

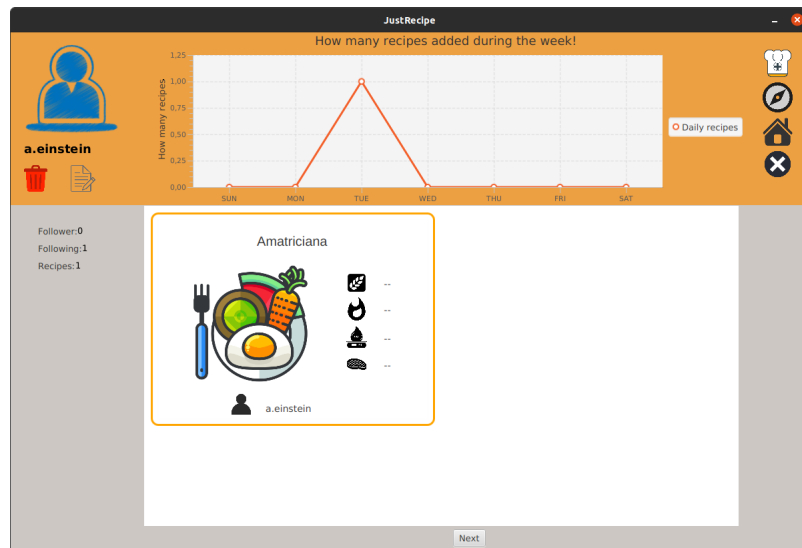


Figure 4.20: Logged User Profile after the addition of a new recipe

Now if we want to modify the user profile we can click on the proper icon as we previously said. So the page in figure 4.21 will be shown.

Edit Profile

Username: a.einstein

First Name:

Last Name:

New Password:

Confirm Password:

Url Picture:

Role: Normal User

You cannot change your own role!

Figure 4.21: Edit Profile Page

In order to change something, the user must change the correspondent entry and then he can click on **Apply Changes**. He can go to his profile clicking on the profile icon or on the button **Back To Profile**. It's important to underline that if the user who is performing changes is the admin or the moderator, the **Back To Profile** button will show the page of the user who

owns this edit page and not the profile page of the user who is performing the changes, more details afterwards. The *username* cannot be changed. For instance let's try to change image. We can put the link of the image in the section **URL Picture** and then we can click on **Profile Picture Preview** to see a preview of the image. Be careful: only after the click on **Apply Changes** the image changes, otherwise it remains the same of before. So clicking on **Profile Picture Preview** has the only effect of visualize a preview. We can see an example in the figures 4.22 and 4.23.

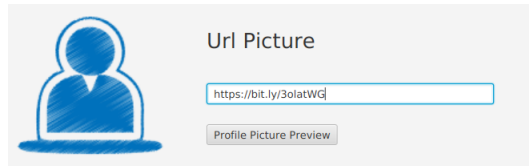


Figure 4.22: Before the preview

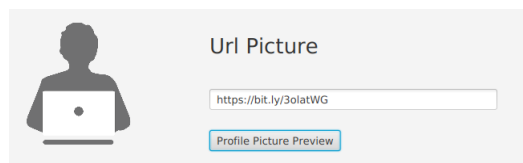


Figure 4.23: After the click on preview button

4.5 How To Handle A Recipe

When the user is on a page of its recipe he can *modify* and *delete* it. The icon are the ones showed in the figure 4.24.

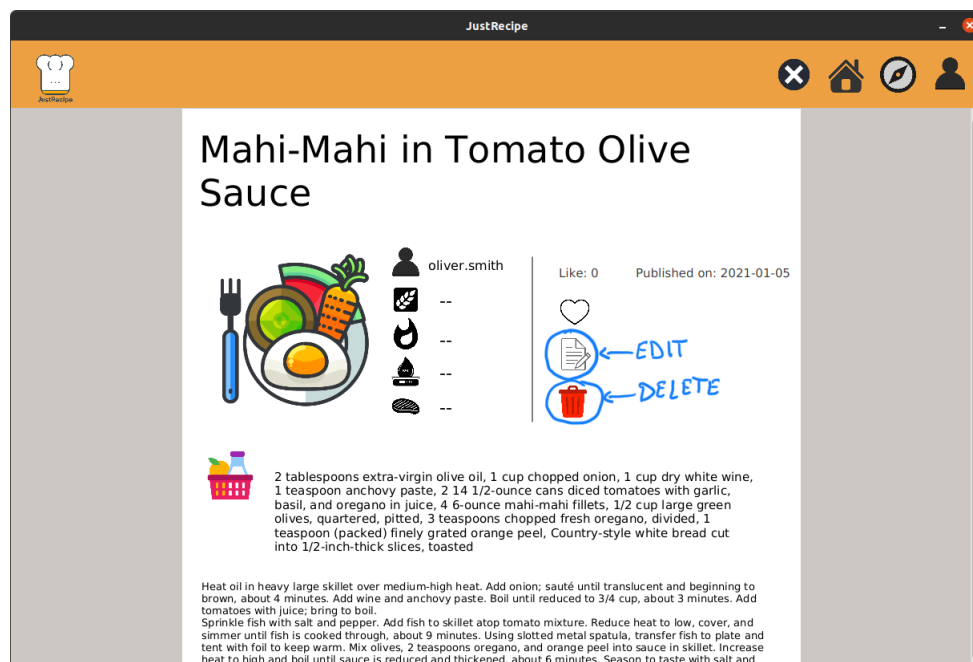







Figure 4.24: Page of a logged user's recipe

If the user clicks on delete the recipe will be delete permanently. If the user clicks on edit the page in figure 4.25 will be shown. For the update of a recipe the same consideration made for the addition must be taken into account. Furthermore the title of the recipe *cannot be changed*.

JustRecipe



Update Recipe



Insert Title:

Mahi-Mahi in Tomato Oil

URL Picture:

Insert Calories:

0

Kcal

Insert Carbs:

0

g

Insert Fat:

0

g

Insert Protein:

0

g

Insert Categories (separate with ','):

Fish, Olive, Tomato, Sauté, Low F

Insert Ingredients (separate with ','):

2 tablespoons extra-virgin olive oil, 1 cup chopp

Insert Instructions:

Heat oil in heavy large skillet over medium-high
Sprinkle fish with salt and pepper. Add fish to sk

Clear

Submit

Figure 4.25: Edit page of a logged user's recipe

4.6 How To Handle Comments

In Figure 4.26 there is an example of comments, one of the comment has been sent from the author of the recipe post, the other one has been sent from another user. The user who made the recipe post is a normal user (no a moderator nor an administrator). Here (Figure 4.26)

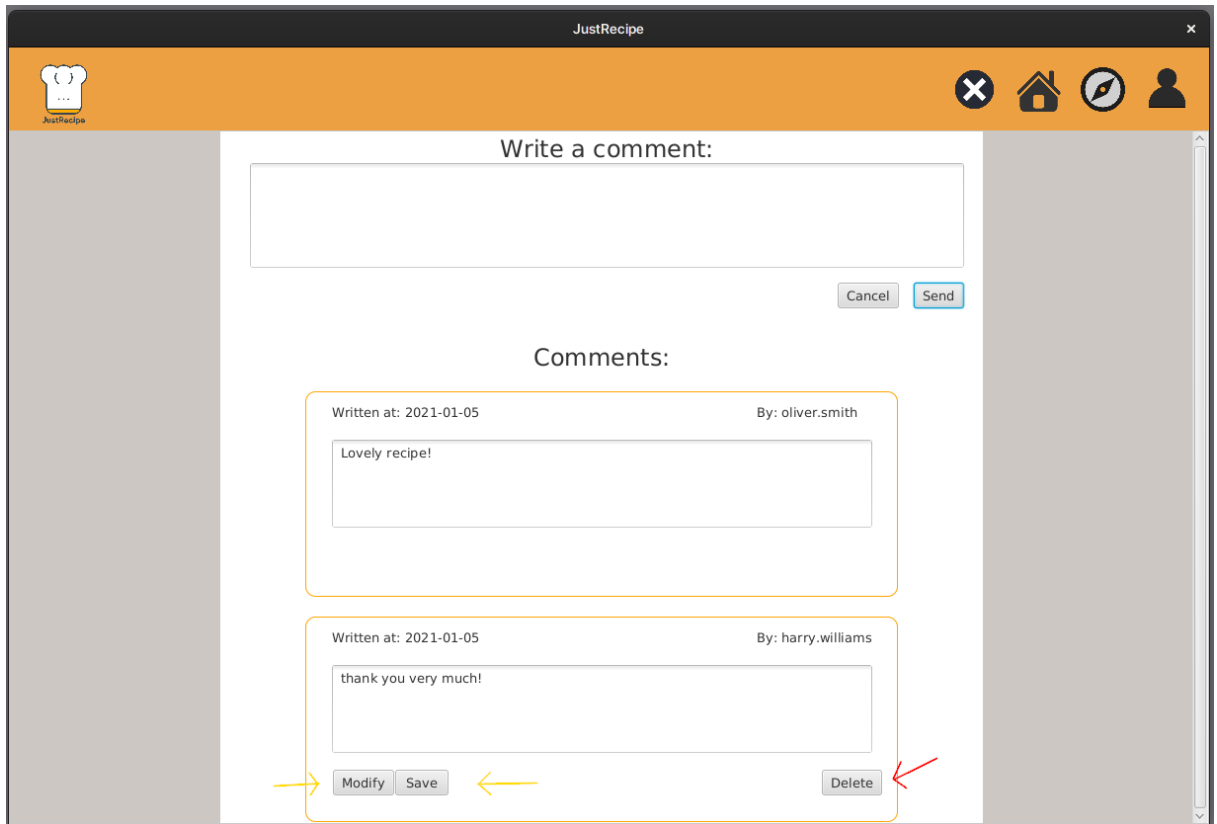


Figure 4.26: How to comments(1)

the first comment has been sent from oliver.smith (an administrator), the second one from harry.williams, the one who also posted the recipe, and the logged user (a normal user). Here the logged user (harry.williams) can:

- add others comments
- delete his own comment by clicking on delete button (following the red arrow in Figure 4.26)
- modify his own comment, by clicking on the modify button (yellow arrow), so changing the text of his comment and clicking on the save button (yellow arrow) in order to save the changes just done.

A user with the moderator role (or administrator role) can delete a comment who have not posted.

4.7 Suggested recipes realistic use

In the Discovery page (see section 4.3) the user can take a look at the suggested recipes. In Figure 4.27 there is a realistic discovery page, where there are not loaded the best recipes but there are the suggested recipes for the logged user, the usernames underlined are users that are followed from the logged user or they have added a recipes that have received likes from the user that are followed from the logged user.

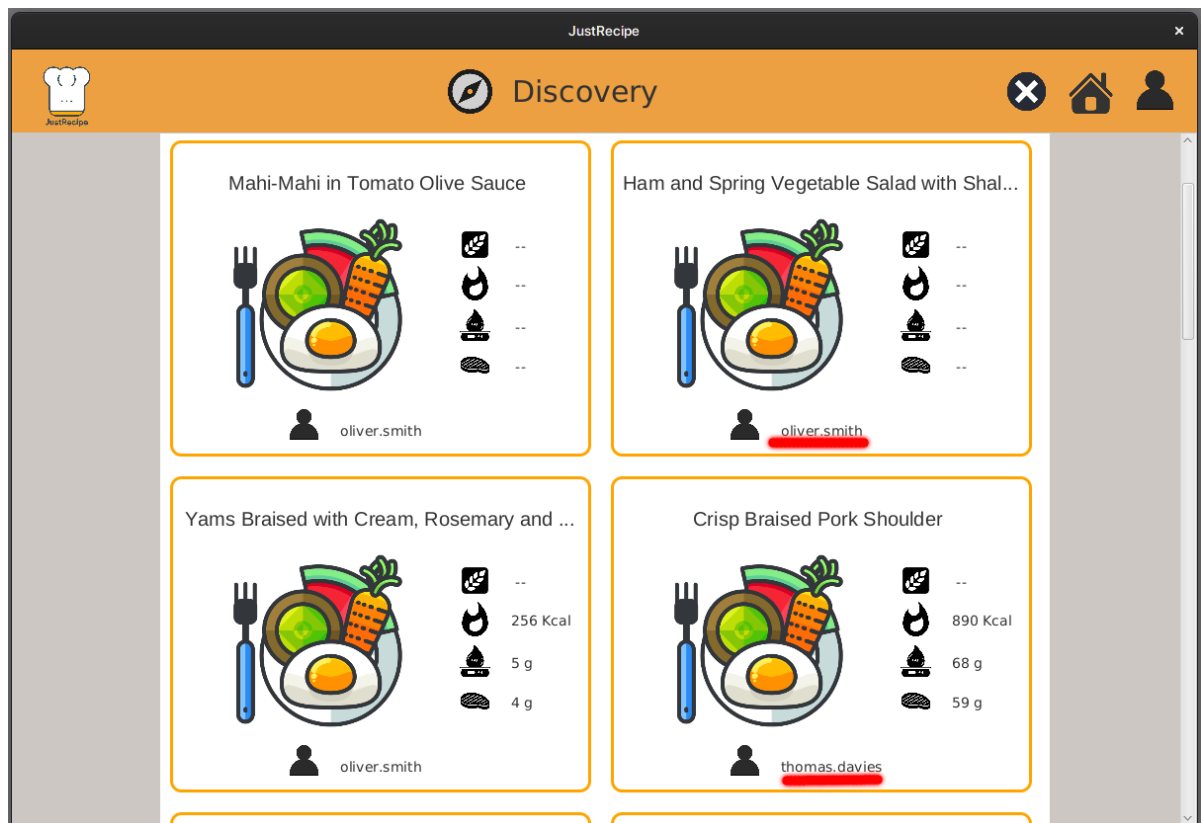


Figure 4.27: Suggested recipes realistic use

4.8 DiscoveryPage ComboBox Explanation

Into the discovery page, there is a combo box (framed in red in Figure 4.28). This UI Input let the user discover a lot of recipes and users. It is very simple, You have to click on the combobox in order to choose what query you want to perform. In same case (recipe title, categories, ingredients, user username, fullname) you have to digit what you want to find into the text field, next to the combo box; in every case, after selected the query from the combobox, you have to click on the search button (framed in yellow in figure 4.28) to actually perform the query selected.

Now lets see some of the possible outcomes.

- **Recipes Outcomes** - clicking on a specific result you will be transported into the specific recipe page.

In figure 4.29 is possible to see an example of a list of recipe as result of the query. In this case the query is most versatile user recipes, as combobox suggests, this particular type of query does not have to digit something into the text field next to the combobox.

- **User Outcomes** - clicking on a specific result you will be transported into the specific user profile page.

In figure 4.30 is possible to see an example of a list (of one in this particular example) of users as result of the query, which in this case had to be completed by digit part of the username (or the complete one) of an user

4.9 Moderator Functions

A moderator in his own profile will have access to the administration page, by clicking on the icon framed in red in Figure 4.31.

The Figure 4.32 shows the administration page, in this page the moderator can see all the comments by descending order, and delete the one inappropriate.

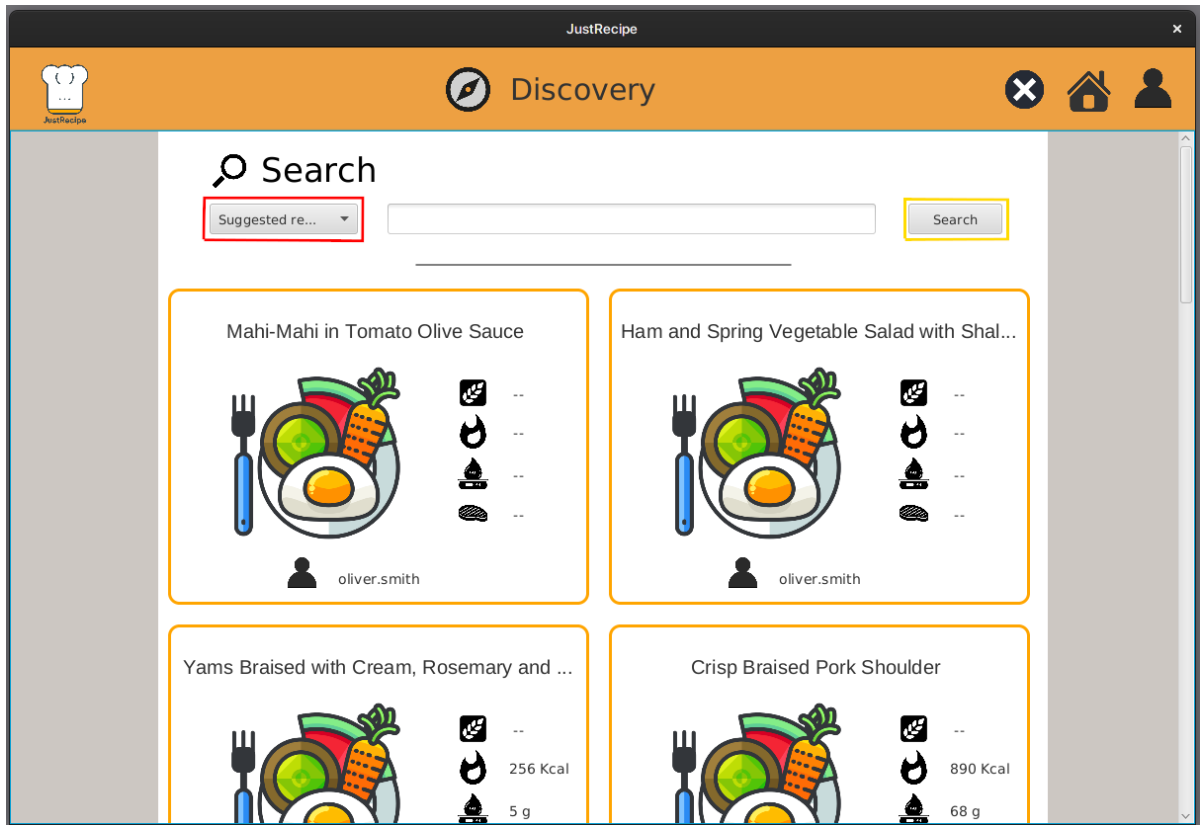


Figure 4.28: DiscoveryPage ComboBox Explenation(0)

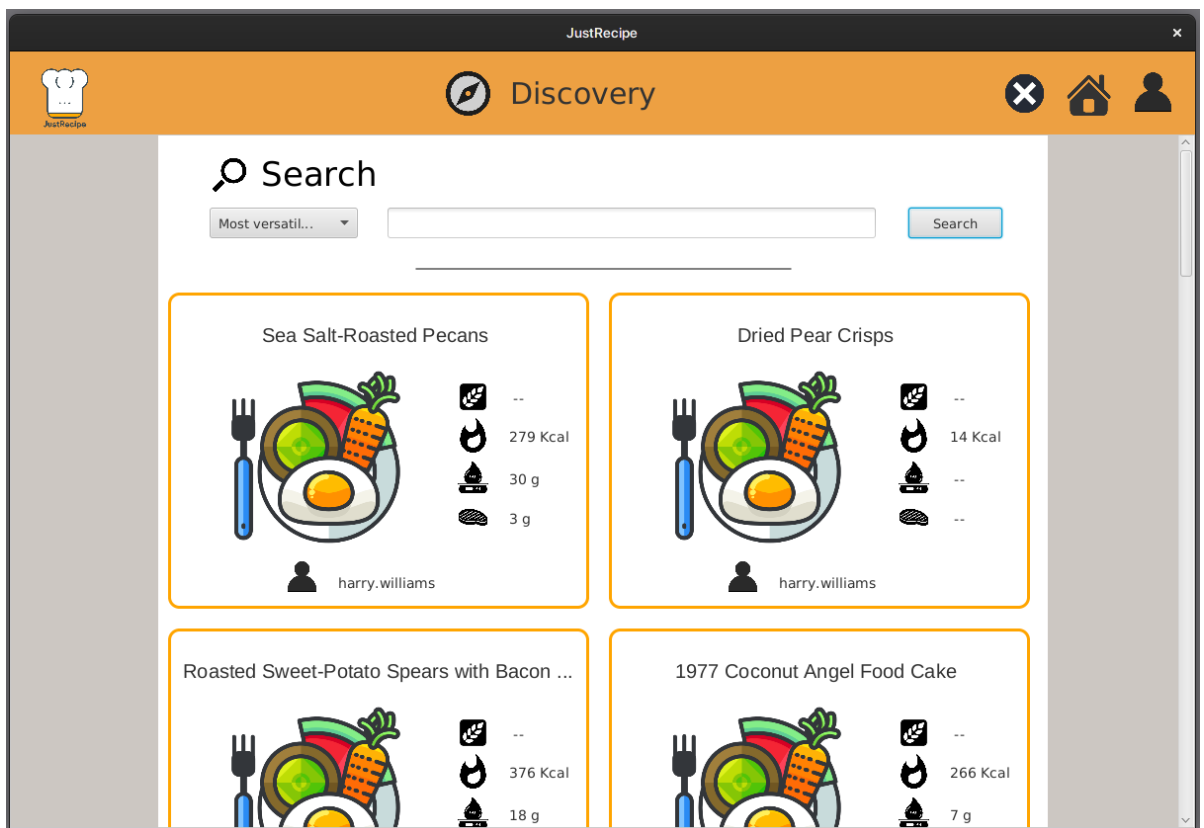


Figure 4.29: DiscoveryPage ComboBox Explenation(1)

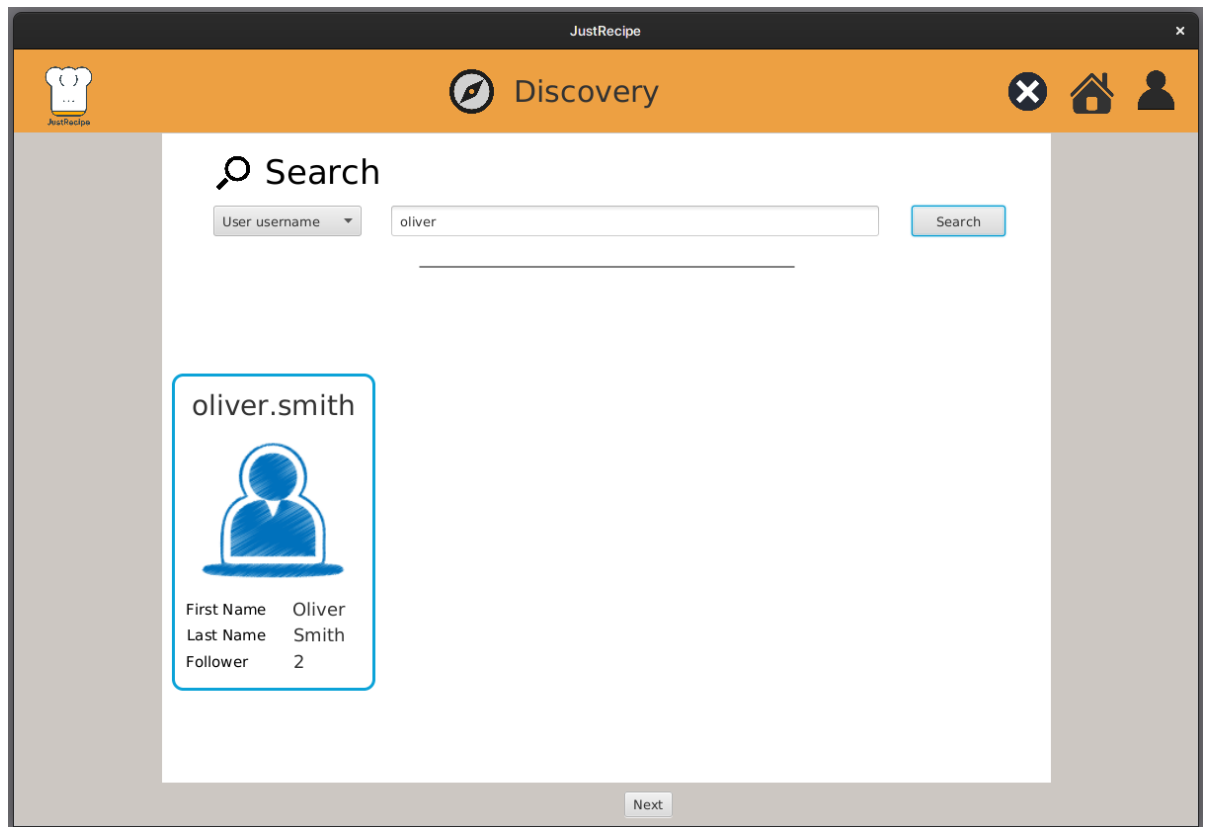


Figure 4.30: DiscoveryPage ComboBox Explanation(2)

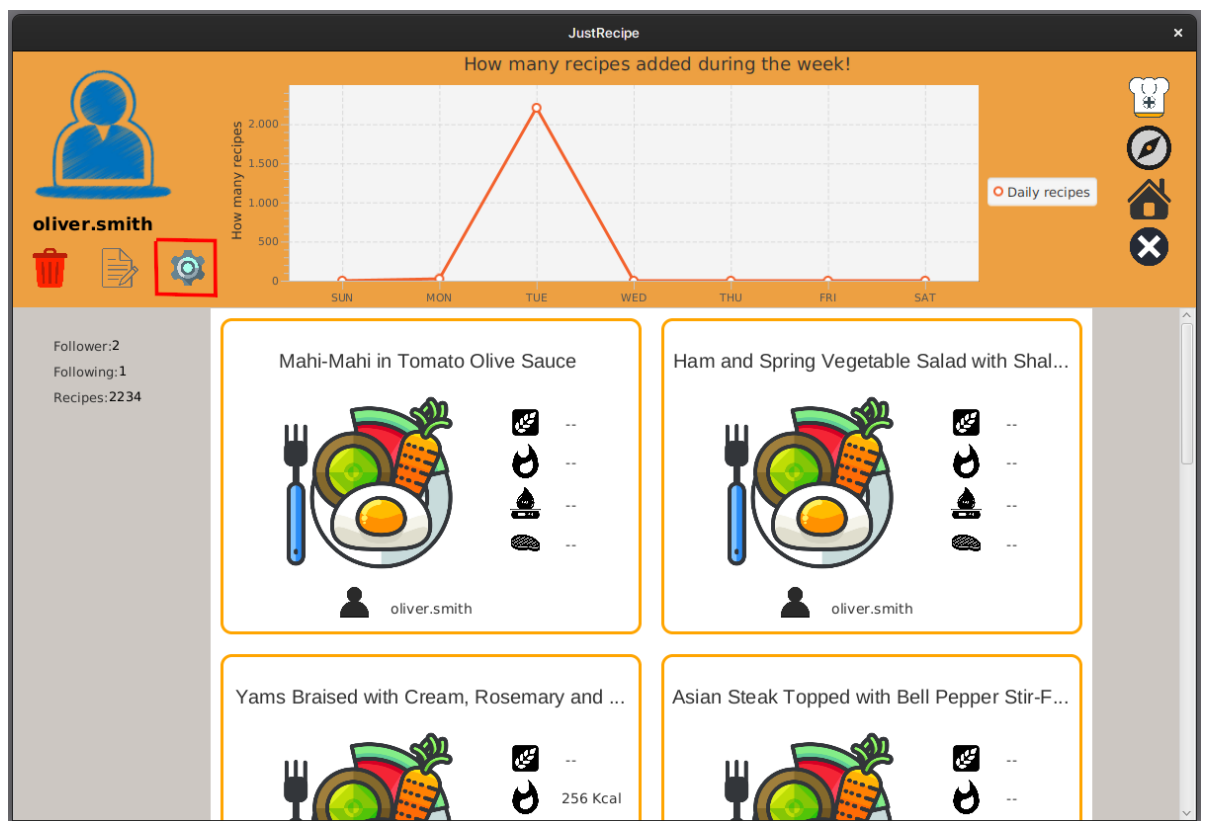


Figure 4.31: Moderator Functions(0)

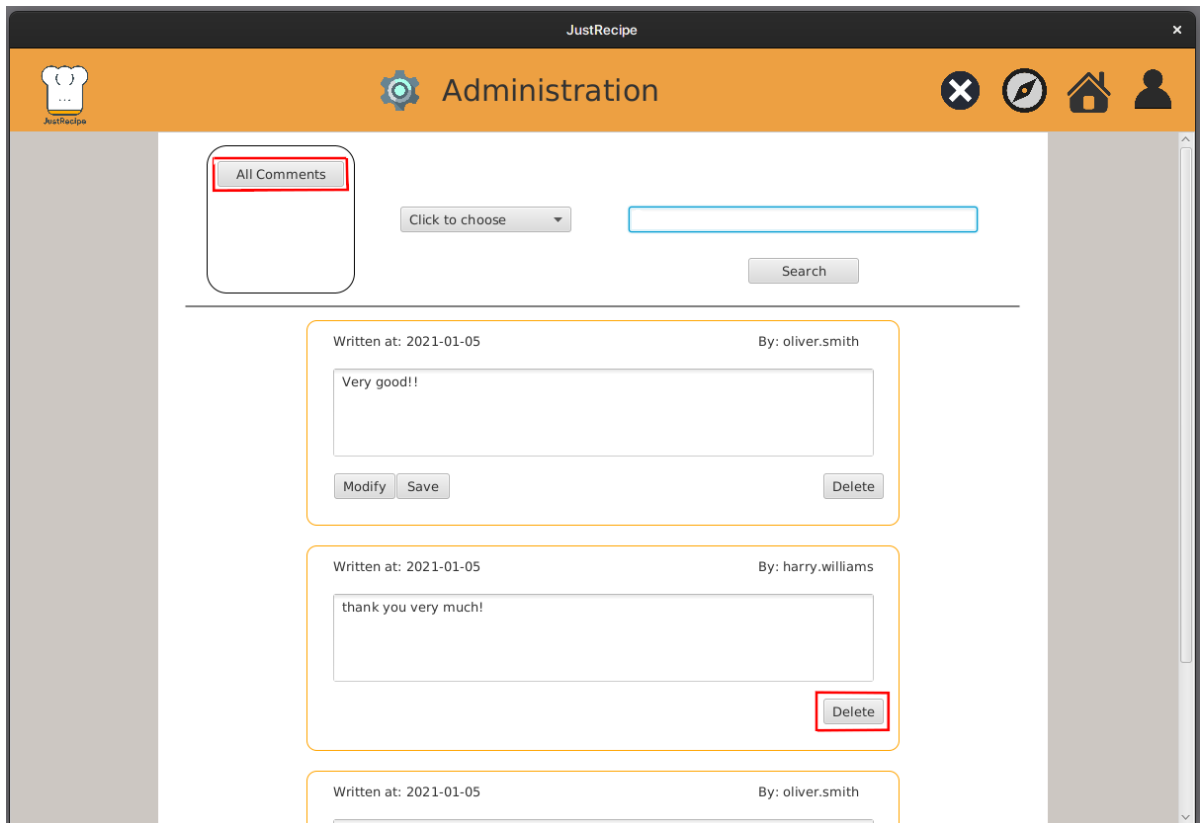


Figure 4.32: Moderator Functions(1)

The moderator can also delete the comments on the recipe page, where the comments usually are shown. The first comment shown in figure 4.32 is made by the logged user, which is also a moderator, this explain why there is also the modify and save button.

4.10 Administrator Functions

Here are shown all the possibilities for the administrator, the administrator page is accessible by clicking on the framed icon in figure 4.31 (as for the moderator).

In this case the administrator has two more available buttons (Figure 4.33) **All Recipes** and **All Users** which show all the Recipes like in Figure 4.34 and all the Users like in Figure 4.35, in order to delete or access them in a fast and comfortable way.

But in order to have a more precisely search, using the combo box (red framed in figure 4.36) is possible to search user for username or full name, and search a specific recipe by title.

An example of search for a user in Figure 4.36 and search for a specific recipes name in Figure 4.37.

Another important admin jobs are, electing/dismissing the moderator and electing other admins. This actions are possible by selecting the user you want to elect moderator (or administrator) and clicking on the icon framed in red in figure 4.38.

This will open a new page, the one in Figure 4.39, that let the Admin all the possibilities to elect new moderators and administrator.

In this case (Figure 4.39) the user thomas.davies is a normal user and clicking on the Elect Moderator button, framed in yellow, will make thomas a moderator or clicking on the Elect Administrator button, framed in yellow too, will make him an administrator.

Than confirm the operation by clicking on the apply changes button framed in red, the action will take effect, or going back to thomas profile page, by selecting the Back to Profile button framed in blue in Figure 4.39.

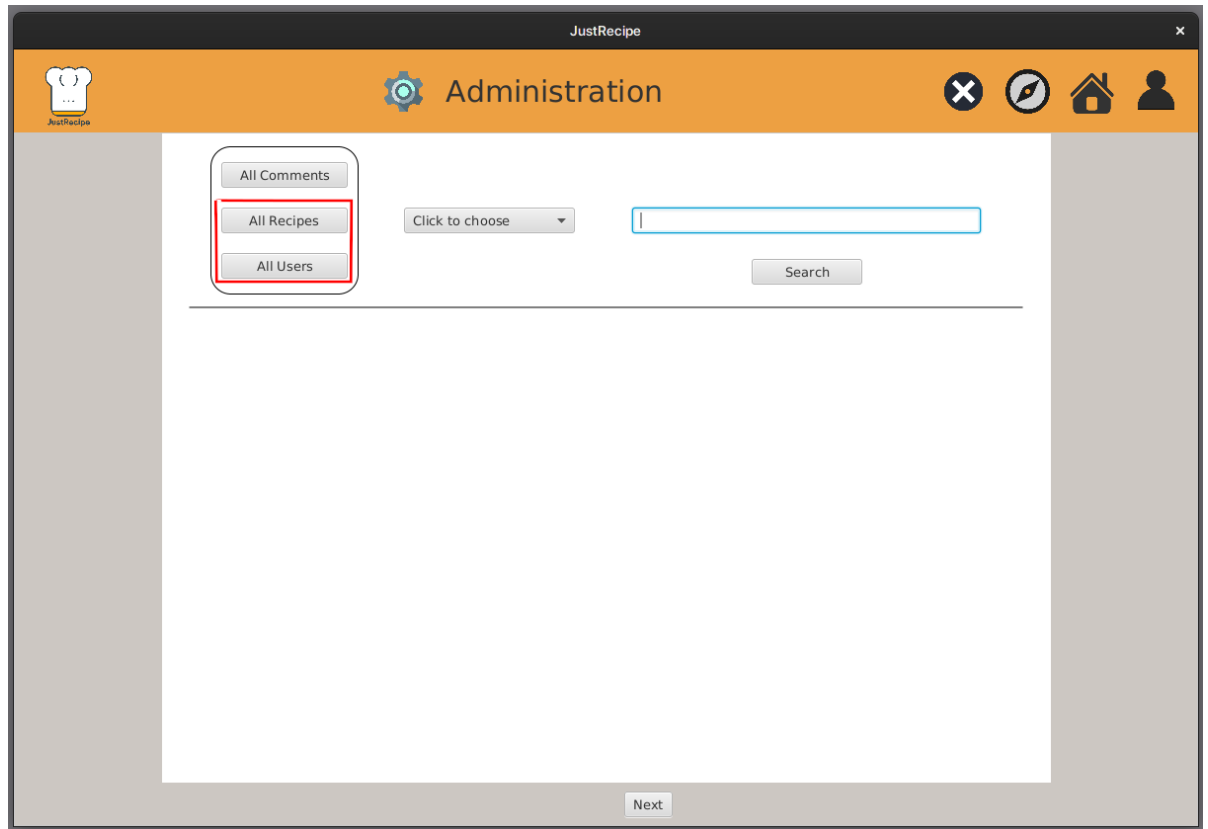


Figure 4.33: Administrator Functions(0)

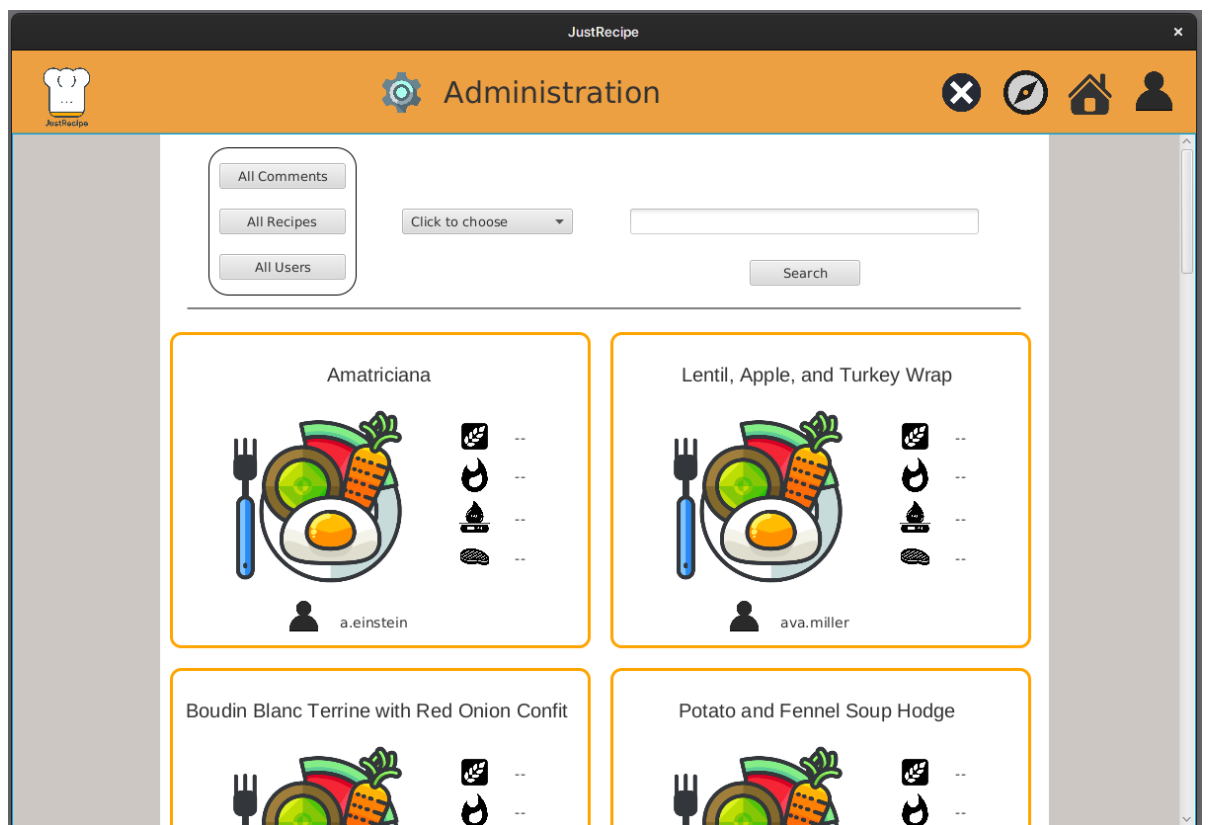


Figure 4.34: Administrator Functions(1)

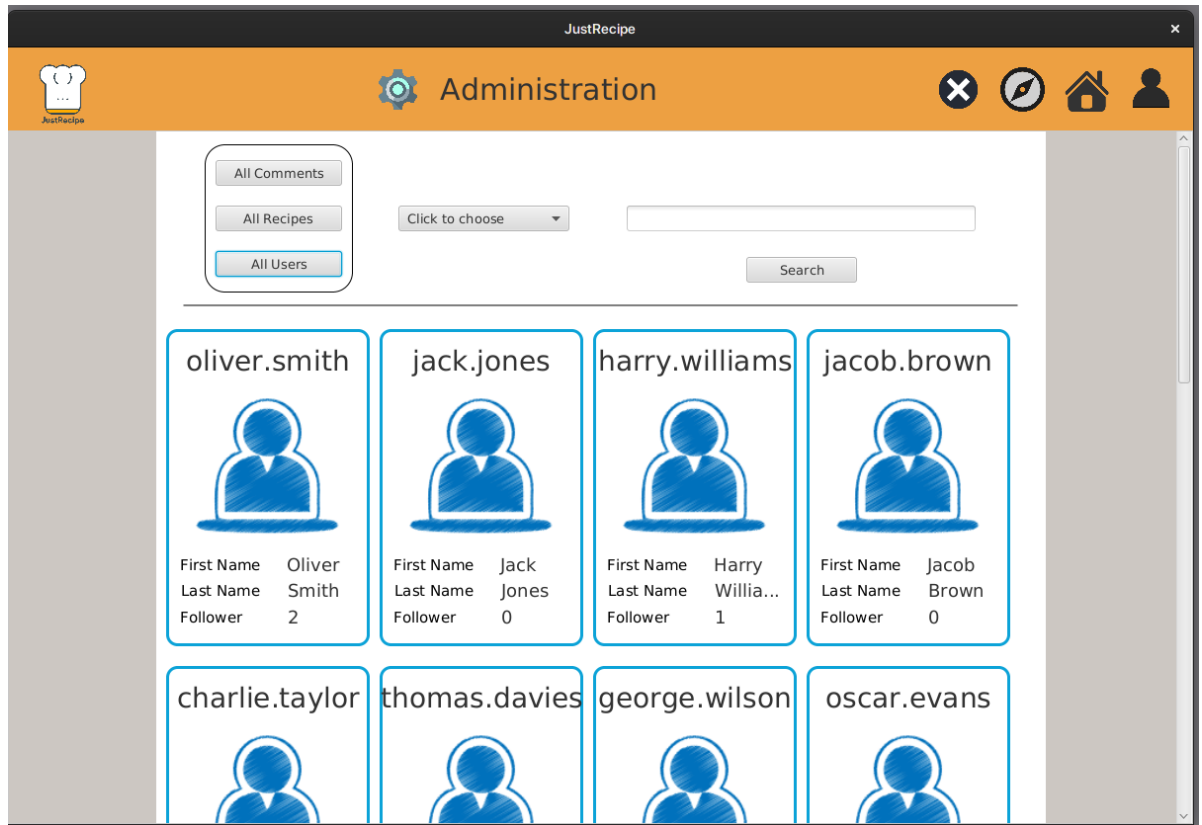


Figure 4.35: Administrator Functions(2)

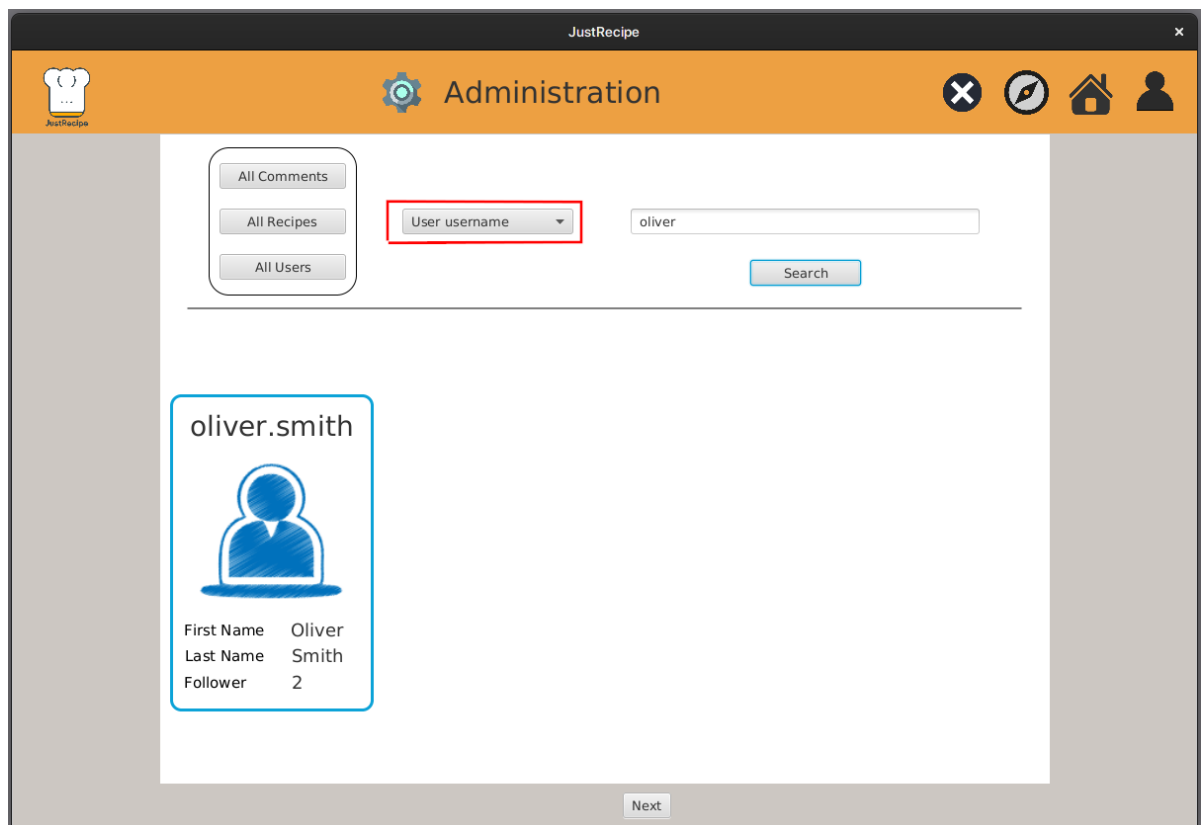


Figure 4.36: Administrator Functions(3)

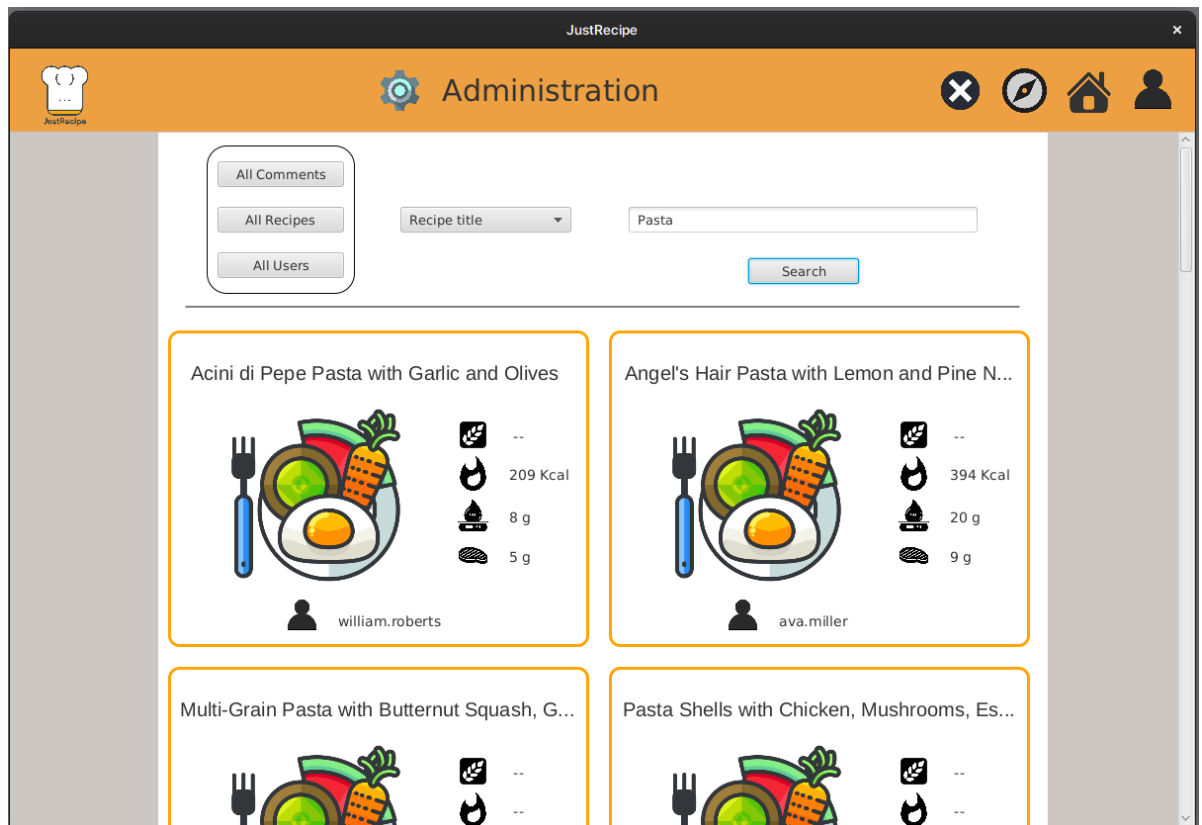


Figure 4.37: Administrator Functions(4)



Figure 4.38: Administrator Functions(5)

JustRecipe

Edit Profile

Username: thomas.davies

First Name: Thomas

Last Name: Davies

New Password:

Confirm Password:

Url Picture:

Profile Picture Preview

Role: Normal User

Elect Moderator

Elect Administrator

Back To Profile

Apply Changes

Figure 4.39: Administrator Functions(6)

4.11 Logout

The Logout icon is the one in Figure 4.40, it is present in almost all the pages of the application and just by pressing it let you log out and go back to the welcome page (Figure 4.1) from wherever your page is.



Figure 4.40: Logout Icon