universidade de aveiro

Software Quality and Tests
Homework 1 : Test Development

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Repository: `https://github.com/aspedrosa/weather_forecast/`

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1 Intro

This homework consisted in developing a web project that allows to see the meteorology state for the next days, for a specific location, with the main goal being to develop the different classes of tests (unitary, integration and functional) along with the development of the project.

The main components of the solution are:

- **Web page**, allowing the user to select and search for locations and also giving the choice to the user to choose how many days of forecast data he wants to see.
- **Rest API**, that can be called by external clients allowing to query the meteorology state for a specific location.
- **Integration with an external source**, from where the real meteorologic data will be obtained, so the app built is a client of another source.
- **Caching mechanism**, where is stored the last retrieved results from recent calls to the external sources, having also some statistics about its functioning (number of requests, hits and misses)

For the website jQuery and Bootstrap was used. To implement the server side logic a web application was built using SpringBoot.

2 Solution

2.1 Front End

The front end consists on a single minimalist page, where the user can do every thing that the system allows on one page.

At the start the user can either search from a specific location or use the "I'm Feeling Lucky" feature where the meteorology state for the first location found on the results of the search mechanism is displayed. At this time the user also can choose how much days of meteorologic data he wants to see.

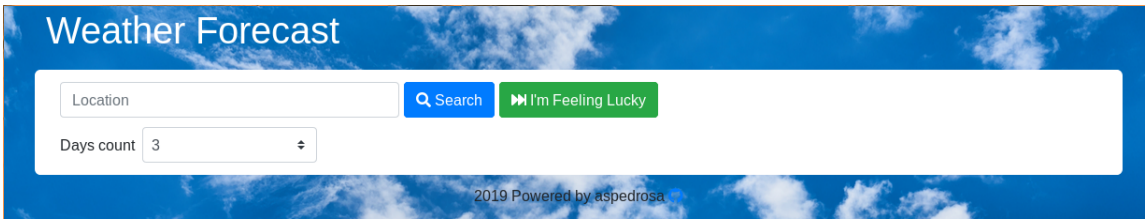


Figure 1: How the web page is displayed at the beginning

Once the user searches for a location, a table appears with the names of related location as well as the respective geographic coordinates.

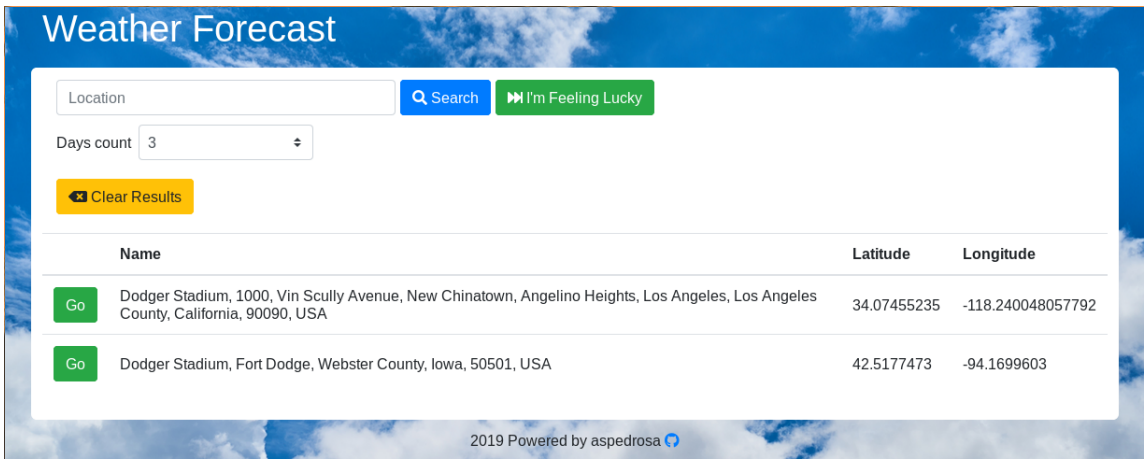


Figure 2: Search results for "dodger stadium"

When the user chooses a location two types of forecast data is displayed. Current and for future days, being the number of days the same as the value on the "Days Count" select html tag.

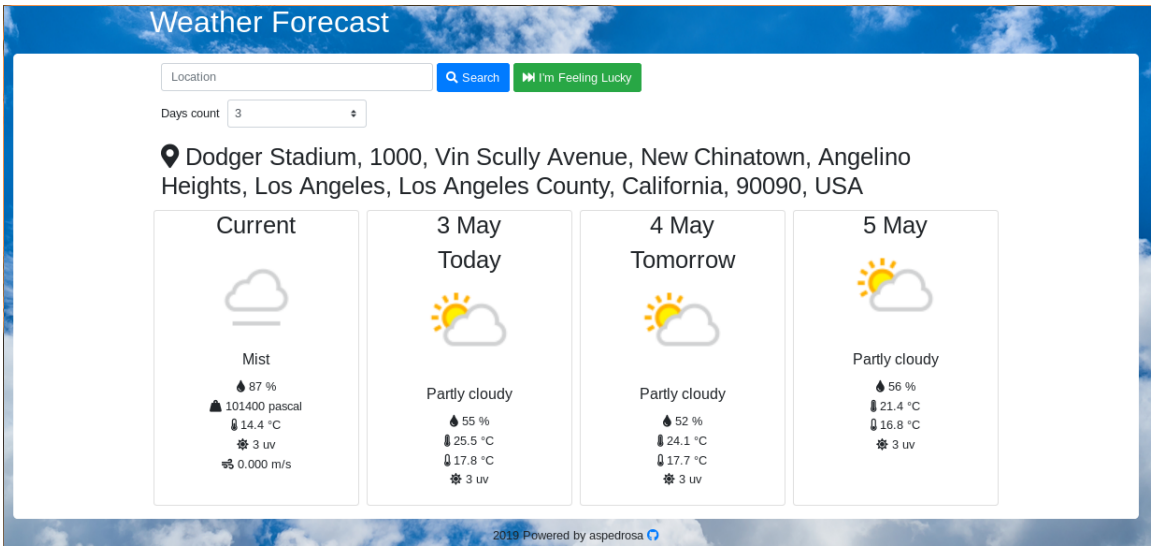


Figure 3: Forecast data for "Dodger Stadium, California, USA"

2.2 Back End

As mentioned before, back end uses SpringBoot, that divides the system in three layers. Controllers, that process HTTP requests and pass the received data to the service layer. The service layer imposes the business logic. The last layer is the repositories where the service layers can store data.

On figure 4 is shown the several layers of the application as well as the classes in each one.

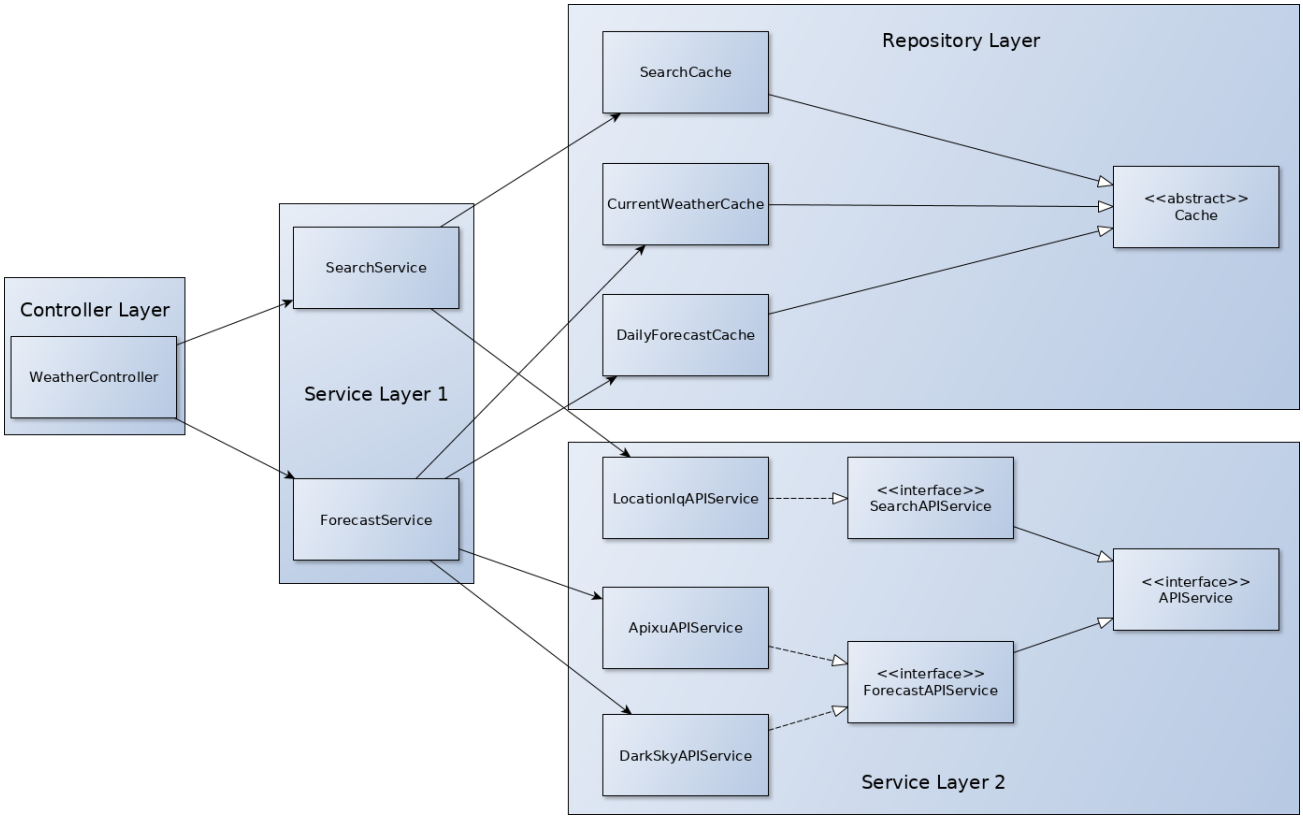


Figure 4: Class diagram for the solution implemented

Abstraction where used to allow extensibility to the application such as caching new types of data, using other external apis and using other external apis for new types of data.

2.2.1 Controller

The controller layer is composed by a single controller where the REST API is defined. Has two paths:

- api/forecast : Obtains meteorologic data of a location
  - latitude : double : request parameter - mandatory : latitude of the location
  - longitude : double : request parameter - mandatory : longitude of the location
  - days_count : int : request parameter : how much days of forecast data to retrieve
- api/search : searches for a location. Used to obtain geographic coordinates
  - location : String : request parameter - mandatory : location to search for.

The controller is also responsible to validate to parameters received before sending them to the first service layer (i.e. latitude must be a double).

2.2.2 Services

Is composed by the upper layer (Service Layer 1) and the lower layer (Service Layer 2). The upper layers is used by the WeatherController class and its role is to check the cache for the requested data and if it is not there should interact with the lower layer. The role of the lower layer is to retrieve meteorologic from the external api. Whenever the upper layer contacts the lower layer to get data it must store that received data in the cache.

The upper layer is composed by two services, Search and Forecast. Both follow the flow mentioned previously, however the Forecast service as a complexer logic to when query the lower layer. First the Forecast service is in charge of two types of data, current and daily forecast, leading to two caches with different expiration times. Secondly the Forecast service uses two services of the lower layer. One used as a primary and other as backup in case the primary fails. Furthermore, if the client asks for a high number of days of forecast data, the Forecast service tries to use the one that offers the higrer number of days of forecast data.

```
/*
 * if the number of requested days is higher than the ones
 *  the primary api can give and the backup api can
 *  give more days, use the backup api
*/
if (days_count > primary_api_service.MAX_DAYS_COUNT()
    &&
    primary_api_service.MAX_DAYS_COUNT() < backup_api_service.MAX_DAYS_COUNT())
    try {
        forecast = backup_api_service.forecast(latitude, longitude);
    } catch (RestClientException e) {
        forecast = primary_api_service.forecast(latitude, longitude);
    }
//Otherwise use the primary api
else
    try {
        forecast = primary_api_service.forecast(latitude, longitude);
    } catch (RestClientException e) {
        forecast = backup_api_service.forecast(latitude, longitude);
    }
```

Figure 5: Block of code of the function retrieve_from_apis of the class ForecastService where the choice of which api to use happens

Third both current and daily data are retrieved on one call to an external api. So, if the current data expires, both current and daily data will be stored in cache after the call and overwriting of existing data may occur but because the new data is more recent, is more accurate, so overwriting ends up being a good thing.

2.2.3 Repositories

The repository layer is in charge implementing caching mechanisms for the application. This is done associating data to a key, in other words, a map was used. Each cached data has a time-

to-live after which the data stored is not valid and if clients asks for that data, should consider as not not having that data cached.

Different types of data have different strategies to see if it had expired. For current meteorologic data and search data is just checking, whenever its requested, if a certain time has passed since the last write (30 days for search data, because location data it's pretty stable and 15 min for current meteorologic data). In this cases the data associated is just removed if its considered as expired. For daily forecast all data isn't removed since daily forecast data can be associated with several days, witch means is a list of values each position associated with a different day. So the data "expires" when the current date is in a different date comparing to the date on the last write (i.e. if data is stored at 12/05/2019 10:00, at 12/05/2019 15:00 is still valid but at 13/05/2019 10:00 isn't). When this happens the data needs to be shifted the difference of days since of last write, however if the number of days that had passed is higher than the number of days stored than the data is just removed.

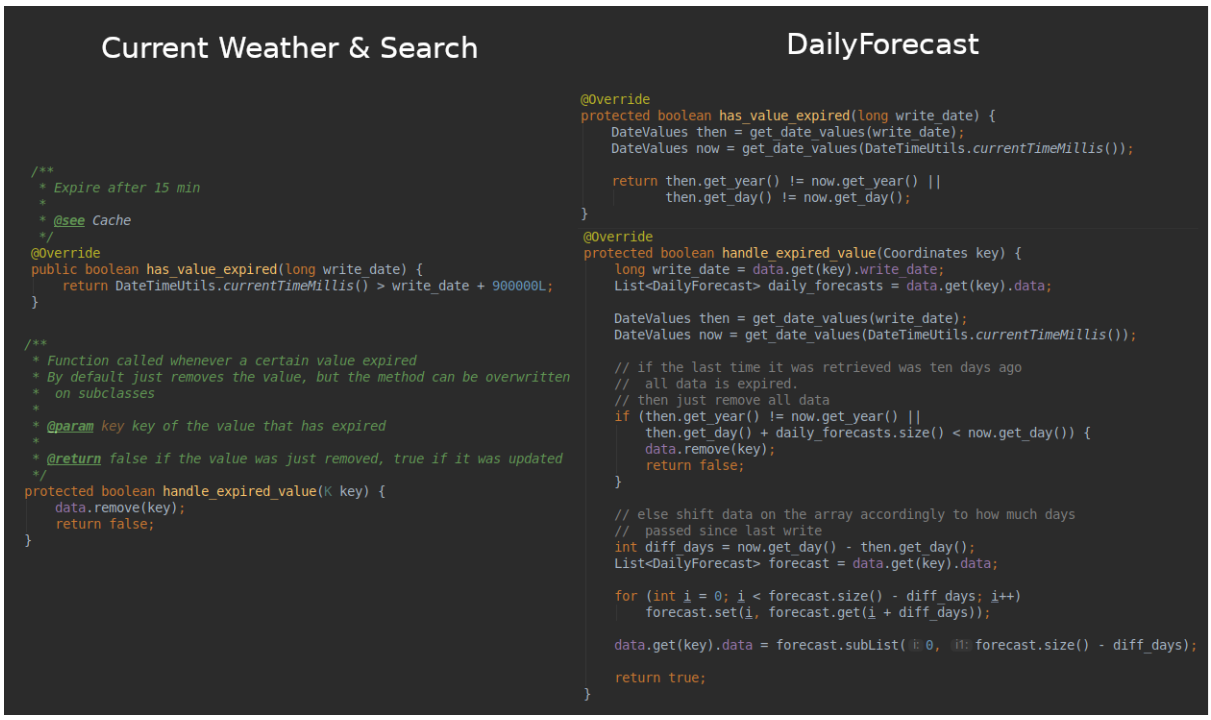


Figure 6: Difference of cache strategies between current weather and search and daily forecast. The two methods here shown are called whenever the cache is queried for data. If the method has_value_expired returns true then the method handle_expired_value is called. On the method get_cached_data of the class Cache its clear what happens when the system tries to get cached data.

3 Tests

As said in the Intro, the main goal of this homework is to develop a project with test development along. On this section it is explained what tests were made and how they were made.

3.1 Front End

Here functional tests were made that validate the functional requirements for the application such as:

- give an error if the user inserts an unknown location
- the number of days of forecast data displayed must be the same as the number of days requested
- give an error if the user insert an invalid location
- when the user uses the I'm Feeling Lucky feature, the forecast data should be displayed, without asking to choose a location

Because this the web page uses the api developed, its response to the web page was mocked with deterministic responses using Mockito.

3.2 Back End

3.2.1 Controller

Here is tested the responsibilities of the controllers:

- generate the response accordingly to the response received from the service layer
- validation of the parameters received

The integration tests for controllers were done by mocking the service layers and the application context is restricted to Model-View-Controller(MVC) components.

3.2.2 Services

For integration tests of the upper layer the lower layer services and repositories were mocked allowing to test:

- ForecastService
  - usage of the cache
  - query external api when one of the cache doesn't satisfies the request (i.e. number of days requested is higher than the days stored or no current data cached)
  - choice between the primary and backup api according to number of days requested

  - choice between the primary and backup api according to availability

- SearchService
  - successful responses
  - not found location

For the lower layer only unitests were made mocking the response of the external api. For the services that implement the interface ForecastAPIService (DarkSkyAPIService and ApixuAPIService) it was tested:

- the conversion of weather metrics to si units
- number of days processed and generated had to be the same as the number of days received from the external api

For the services that implement the SearchAPIService (LocationIqAPIService) it was tested:

- handle the user inserting an unknown location leading to no results
- handle receiving multiple entries with the same name from the external api

3.2.3 Repositories

To test the layer of repositories only units were done. Because the class SearchCache and CurrentWeatherCache only change the time-to-live comparing to their super class, these classes were not tested however their super class, abstract, was tested by creating a new implementation during the tests with a low time-to-live making tests doable:

- receiving null after time-to-live
- receive data after insert
- not receiving data if no inserted were made
- overwrite and update of data updates write date

For some of these tests an external library(Awaitility) was used that allows to verify a condition during a certain time. If at the end of that time the condition is not met, the test fails. At first the Thread.sleep method was used but Sonarcloud didn't recommended that method.

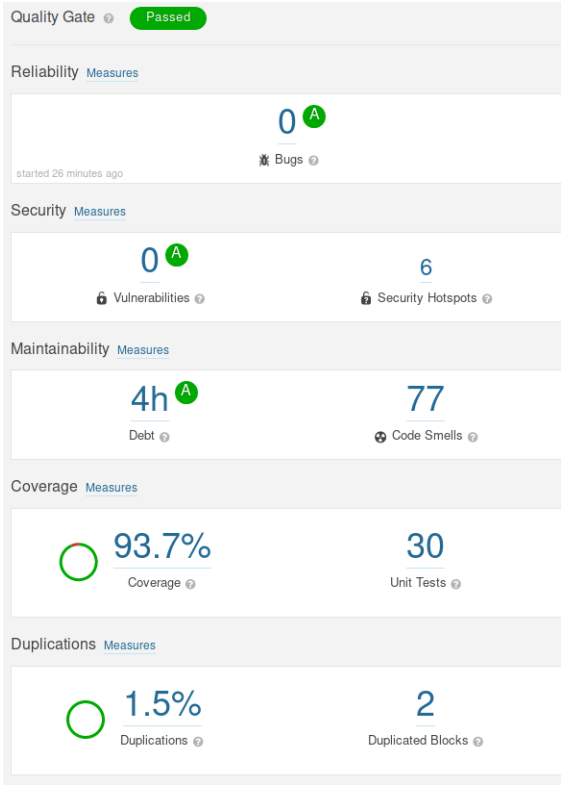
Because the DailyForecastCache has different ways to handle data expiration and the expiration itself is different separate tests were done for:

- expired data is correctly handled
- data expires on the correct time
- the action of overriding data is done correctly

To test the expiration of the data an external library (joda-time) was used to allow control of time. Basically whenever the current time is needed on the application this a function from this library is used to allow control of time during tests.

4 Sonarcloud

For static code analysis I used Sonarcloud (`https://sonarcloud.io/dashboard?id=aspedrosa_weather_forecast`).



Currently, the project has 93.7% code coverage and 30 unit tests. 77 code smells are present because sonarcloud uses a different naming convention (camel case) from the one used (snake case).

The 2 duplicated blocks are present on the parsing of the response from the external apis. Both use setters of the classes DailyForecast and CurrentWeather to build the response for higher layers but the two external apis used have different response structure making it hard and not code friendly to eliminate these duplicated blocks.

The 6 security hotstops concern security problems that can exists. The problems that were mentioned were related to user input such as command line arguments (not used), HTTP arguments (in case of the /api/forecast path, request parameters are checked against a regex) and using regex for user input check (sonarcloud warns that for complicated regexs, the verification can

take a lot of cpu load, however the regexs used are basic and don't have heavy recursions such as *(a+)+*).