

HW1: Mid-term assignment report

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1 Introduction

1.1 Overview of the work

This report presents the midterm individual project required for TQS, covering both the software product features and the adopted quality assurance strategy. The application made, Air Quality, has the goal of providing the Air Quality data of a certain location, given its geographical coordinates.

1.2 Current limitations

There isn't validation of the coordinates data which leads to Whitelabel Error Pages. Additionally, it should check if the API response has relevant data for certain coordinates (some are in the middle of the Artic, and don't have data).

2 Product specification

2.1 Functional scope and supported interactions

The application has 2 ways of interaction: directly, using the front-end, and using de API endpoints created by the application.

Through the front-end there is a simple interface that allows you to input two values, one for latitude and another for longitude, obtaining the wanted location's geographical coordinates.

A screenshot of a web browser window titled "AirQuality". The address bar shows "localhost:8080". The page header includes a logo and the text "AirQuality". Below the header are two input fields: "Latitude" and "Longitude". A button labeled "Search Air Quality" is positioned between them. The entire interface is contained within a light gray box.

After filling those fields with adequate values and clicking in the 'Search Air Quality' button, appears a section below this one with some information about the place of the coordinates inserted and a table with several data related to Air Quality. There is also a description of the initials of the table.

A screenshot of the same web browser window after the "Search Air Quality" button was clicked. The "Latitude" field now contains "40.6442" and the "Longitude" field contains "-8.6108". Below these fields is a "Search Air Quality" button and a "Clear Fields" button. A section titled "City: Aveiro" displays the coordinates and additional details: "Latitude: 40.64° - Longitude: -8.61°", "Country Code: PT, State Code: 02", and "Timezone: Europe/Lisbon". Below this is a table with 12 columns and 2 rows of data. At the bottom, there is a "Field's Description" section with definitions for various abbreviations.

AQI	O3	SO2	NO2	CO	PM10	PM25	PLT	PLG	PLW	ML	PPT
26	57.0	0.414904	2.54903	227.0	0.0	0.0	1	1	1	1	Molds

Field's Description

AQI: Air Quality Index [US - EPA standard 0 - +500]
O3: Concentration of surface O3 ($\mu\text{g}/\text{m}^3$)
SO2: Concentration of surface SO2 ($\mu\text{g}/\text{m}^3$)
NO2: Concentration of surface NO2 ($\mu\text{g}/\text{m}^3$)
CO: Concentration of carbon monoxide ($\mu\text{g}/\text{m}^3$)
PM10: Concentration of particulate matter < 10 microns ($\mu\text{g}/\text{m}^3$)
PM25: Concentration of particulate matter < 2.5 microns ($\mu\text{g}/\text{m}^3$)
PLT: Tree pollen level (0 = None, 1 = Low, 2 = Moderate, 3 = High, 4 = Very High)
PLG: Grass pollen level (0 = None, 1 = Low, 2 = Moderate, 3 = High, 4 = Very High)
PLW: Weed pollen level (0 = None, 1 = Low, 2 = Moderate, 3 = High, 4 = Very High)
ML: Mold level (0 = None, 1 = Low, 2 = Moderate, 3 = High, 4 = Very High)
PPT: Predominant pollen type (Trees/Weeds/Molds/Grasses)

The second way of interacting with this application is by using the API endpoints. [See 2.3]

The REST API invoked to get the air quality data is by WeatherBit.io¹ and it's called with the function callGetAirQualityByLatLon() and requires two doubles, one for the latitude another for the longitude. This method returns a string of the air quality data in a JSON format.

```
public String callGetAirQualityByLatLon(double lat, double lon){
    HttpHeaders headers = new HttpHeaders();
    headers.setAccept(Collections.singletonList(MediaType.APPLICATION_JSON));

    HttpEntity<String> entity = new HttpEntity<>( body: "parameters", headers);

    String url = AIR_QUALITY_DATA + "lat=" + lat + "&lon=" + lon + KEY;
    ResponseEntity<String> result = restTemplate.exchange(url, HttpMethod.GET, entity, String.class);

    return result.getBody();
}
```

The in-memory Cache is implemented by a class called Cache, it has 2 attributes, an integer time-to-live (TTL) and a HashMap<String, CacheObject>. The CacheObject is a class with 2 attributes also, a long that is created when the class is instanced and a string that contains the air quality data in JSON format.

```
public class Cache {
    private final Map<String, CacheObject> cacheMap;
    private final long timeToLive;

    public static class CacheObject {
        private final long lastAccessed = System.currentTimeMillis();
        private final String quality;

        public CacheObject(String quality) {
            this.quality = quality;
        }

        private String getQuality(){
            return this.quality;
        }
    }

    public Cache(long ttl) {
        this.timeToLive = ttl;
        cacheMap = new HashMap<>();
    }
}
```

The Cache class has two main methods, put and get values. The get function checks if it contains that key and, if so, if the TTL has passed, if it has, removes the object from the map, if it hasn't passed, returns the value.

When the user gives the coordinates the home1() function is called. First, it checks if the cache has that air quality data (cache.get()) , if it doesn't the callGetAirQualityByLatLon() function is called. Then with the response from one of the previous methods it's created an

¹ WeatherBit.io: <https://www.weatherbit.io/api/airquality-current>

instance of Quality (the class that has attributes for each of the fields in the JSON string) and sent to the HTML file.

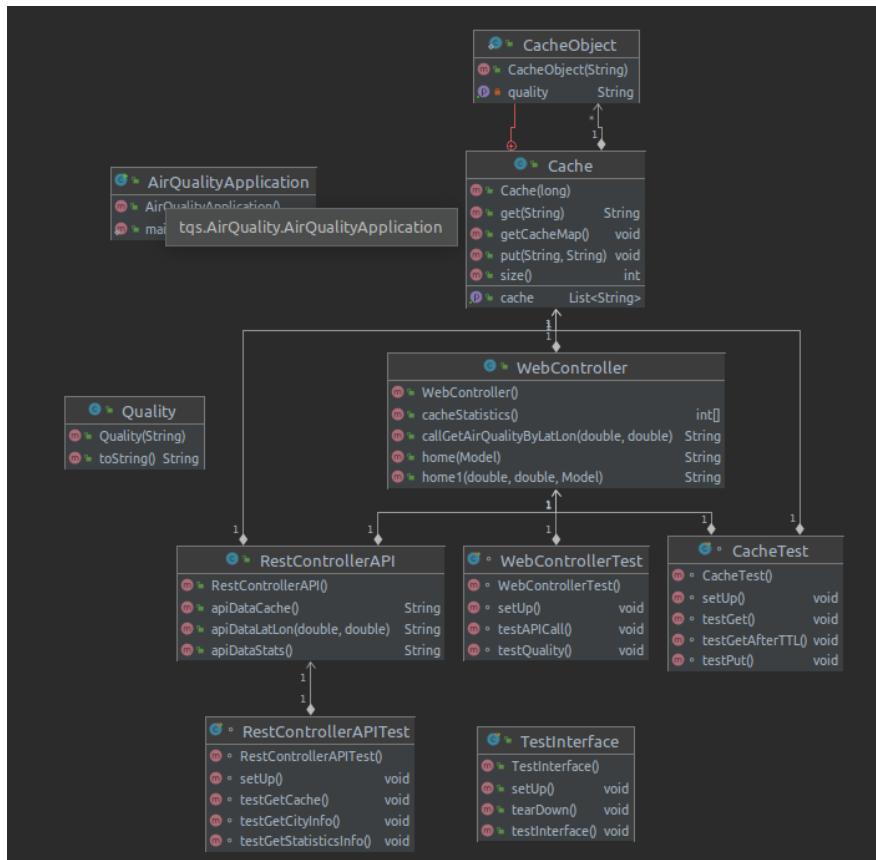
```

@PostMapping(value = "/")
public String home1(@RequestParam(name = "lat") double lat, @RequestParam(name = "lon") double lon, Model model) throws IOException {
    bf = new BufferedWriter(new FileWriter("C:/Users/HP/Desktop/Java/Project/Output/latlon.txt"));
    bf.write(String.format("%s %s \t INFO \t Request for Air Quality of Lat: %f, Lon: %f%n", localDateTime[0], localDateTime[1], lat, lon));
    Quality quality;
    String latlon = lat + "," + lon;
    String qualityJson = cache.get(latlon);

    cache.getCacheMap();
    if (qualityJson == null){
        misses++;
        qualityJson = callGetAirQualityByLatLon(lat, lon);
        cache.put(latlon, qualityJson);
        bf.write(String.format("%s %s \t SUCCESS \t Request Accepted, API returned the result (not found in cache)%n", localDateTime[0], localDateTime[1]));
    }else {
        hits++;
        bf.write(String.format("%s %s \t SUCCESS \t Request Accepted and found in cache%n", localDateTime[0], localDateTime[1]));
    }
    quality = new Quality(qualityJson);
}

```

2.2 System architecture



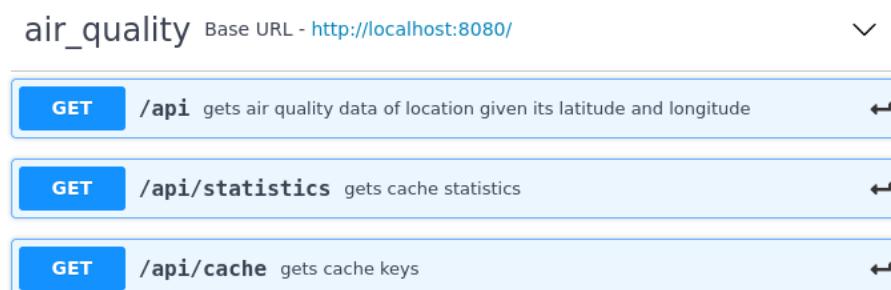
<briefly present the software architecture. Include one or more diagrams.>
<detail the specific technologies/frameworks that were used>

2.3 API for developers

The application's API endpoints can be accessed with the Base URL of localhost:8080/api and has three possible GET requests:

- one for the air quality data given a location's latitude and longitude
- another for the statistics of the cache usage, information on the number of requests, hits and misses and the time to live (TTL) in milliseconds
- and lastly, one that returns the current cache keys

The data for the first endpoint is obtained by the same function used by the WebController, callGetAirQualityByLatLon(),



3 Quality assurance

3.1 Overall strategy for testing

[what was the overall test development strategy? E.g.: did you do TDD? Did you choose to use Cucumber and BDD? Did you mix different testing tools, like REST-Assured and Cucumber?...]

3.2 Unit and integration testing

There are unit tests to verify the cache functionalities. It was made using 3 tests:

- **testPut()**
 - It simulates the insertion after the cache didn't return the location data. **+++**
- **testGet()**
 - It simulates the request of the location's data.
- **testGetAfterTTL()**
 - It simulates the request of the location's data after the TTL.

The first is a simple put, I inserted 3 items in an empty cache and tested that it's size became 3. The next is a get, after the insertion of 3 items it checks if get requests returns the value for its key. The last one is similar to testGet, but here, the test checks if the cache is removing the items after its TTL has passed.

```

    @Test
    void testPut() {
        System.out.println("Size before put" + c.size());
        c.put( key: "38.7452,-9.1604", s1);
        c.put( key: "41.1333,-8.6167", s2);
        c.put( key: "41.1495,-8.6108", s3);
        System.out.println("Size after put" + c.size());
        assertThat(c.size(), is( value: 3));
    }

    @Test
    void testGetAfterTTL() throws InterruptedException{
        c.put( key: "38.7452,-9.1604", s1);

        TimeUnit.MILLISECONDS.sleep( timeout: 500);
        c.put( key: "41.1333,-8.6167", s2);

        TimeUnit.MILLISECONDS.sleep( timeout: 505);
        assertThat(c.get("38.7452,-9.1604"), is(nullValue()));
        assertThat(c.get("41.1333,-8.6167"), is(s2));

        TimeUnit.MILLISECONDS.sleep( timeout: 500);
        assertThat(c.get("41.1333,-8.6167"), is(nullValue()));
    }
}

```

Regarding the WebController tests, mocks were used to simulate the API call, and 2 tests were made, if the mock was correct and if the Quality instance created had the right values.

```

class WebControllerTest {

    double lat = 40.4;
    double lon = -8.5;
    @Mock
    WebController wc;

    @BeforeEach
    void setUp(){
        wc = mock(WebController.class);
        when(wc.callGetAirQualityByLatLon(lat, lon)).thenReturn("{\"data\": [{\"mold_level\":1,\"aqi\":41,\"pm10\":3," +
            "\"co\":235.5,\"o3\":88,\"predominant_pollen_type\":\"Molds\",\"so2\":0,\"pollen_level_tree\":1," +
            "\"pollen_level_weed\":1,\"no2\":1,\"pm25\":0.874739,\"pollen_level_grass\":1}],\"city_name\":\"Mealhada\"," +
            "\"lon\":-8.5,\"timezone\":\"Europe/Lisbon\",\"lat\":40.4,\"country_code\":PT,\"state_code\":02\"\n");
    }

    @Test
    void testAPICall(){
        assertThat(wc.callGetAirQualityByLatLon(lat, lon), is( value: "{\"data\": [{\"mold_level\":1,\"aqi\":41,\"pm10\":3," +
            "\"co\":235.5,\"o3\":88,\"predominant_pollen_type\":\"Molds\",\"so2\":0,\"pollen_level_tree\":1," +
            "\"pollen_level_weed\":1,\"no2\":1,\"pm25\":0.874739,\"pollen_level_grass\":1}],\"city_name\":\"Mealhada\"," +
            "\"lon\":-8.5,\"timezone\":\"Europe/Lisbon\",\"lat\":40.4,\"country_code\":PT,\"state_code\":02\"\n"));
    }

    @Test
    void testQuality(){
        Quality q = new Quality(wc.callGetAirQualityByLatLon(lat, lon));
        assertThat(q.moldLevel, is( value: 1));
        assertThat(q.aqi, is( value: 41));
        assertThat(q.pm10, is( value: 3.0));
        assertThat(q.co, is( value: 235.5));
        assertThat(q.predominantPollenType, is( value: "Molds"));
        assertThat(q.pollenLevelTree, is( value: 1));
        assertThat(q.pollenLevelWeed, is( value: 1));
        assertThat(q.no2, is( value: 1.0));
        assertThat(q.pm25, is( value: 0.874739));
        assertThat(q.pollenLevelGrass, is( value: 1));
        assertThat(q.cityName, is( value: "Mealhada"));
        assertThat(q.lon, is( value: -8.5));
        assertThat(q.timezone, is( value: "Europe/Lisbon"));
        assertThat(q.lat, is( value: 40.4));
        assertThat(q.countryCode, is( value: "PT"));
        assertThat(q.stateCode, is( value: "02"));
    }
}

```

For the integration tests of the API created, its was used MockMVC and 3 tests were made, for each one of the the endpoints:

- **testGetCityInfo()**
 - Checks if the requests made has the city information correct (as the current values of the air quality keep changing, it was only tested the city information)
- **testGetStatisticsInfo()**
 - Checks if is returned
- **testGetCache()**
 - checks if it returns “data”.

```

class RestControllerAPITest {

    MockMvc mockMvc;

    @Mock
    RestControllerAPI rest_controller;

    @BeforeEach
    void setUp() throws IOException {
        rest_controller = new RestControllerAPI();

        mockMvc = MockMvcBuilders.standaloneSetup(rest_controller).build();
    }

    @Test
    void testGetCityInfo() throws Exception {
        mockMvc.perform(get( urlTemplate: "http://localhost:8080/api")
            .param( name: "lat", ...values: "40.4")
            .param( name: "lon", ...values: "-8.5"))
            .andExpect(content().string(containsString( substring: "\"city_name\":\"Mealhada\", \"lon\":-8.5, " +
                "\"timezone\":\"Europe\\Lisbon\", \"lat\":40.4, \"country_code\":\"PT\", \"state_code\":\"02\"")))
            .andExpect(status().isOk());
    }

    @Test
    void testGetStatisticsInfo() throws Exception {
        mockMvc.perform(get( urlTemplate: "http://localhost:8080/api")
            .param( name: "lat", ...values: "40.4")
            .param( name: "lon", ...values: "-8.5"));
        mockMvc.perform(get( urlTemplate: "http://localhost:8080/api/statistics"))
            .andExpect(content().string(containsString( substring: "\"hits\"")))
            .andExpect(content().string(containsString( substring: "\"misses\"")))
            .andExpect(content().string(containsString( substring: "\"requests\"")))
            .andExpect(content().string(containsString( substring: "\"ttl\"")))
            .andExpect(status().isOk());
    }

    @Test
    void testGetCache() throws Exception {
        mockMvc.perform(get( urlTemplate: "http://localhost:8080/api/cache"))
            .andExpect(content().string(containsString( substring: "\"data\"")))
            .andExpect(status().isOk());
    }
}

```

3.3 Functional testing

For the functional tests it was used Selenium Web Driver, because the front-end is very simple, it was only asserted the if values of the coordinates were the same.

```
@Test
public void testInterface() {
    driver.get("http://localhost:8080/");
    driver.manage().window().setSize(new Dimension( width: 840, height: 730));
    driver.findElement(By.id("latID")).click();
    driver.findElement(By.id("latID")).sendKeys( ...charSequences: "40.4");
    driver.findElement(By.id("lonID")).click();
    driver.findElement(By.id("lonID")).sendKeys( ...charSequences: "-8.5");
    driver.findElement(By.cssSelector(".btn")).click();
    driver.findElement(By.cssSelector(".col-12:nth-child(4) > .btn")).click();

    assertThat(driver.findElement(By.id("latID1")).getText(), is( value: ""));
    assertThat(driver.findElement(By.id("lonID1")).getText(), is( value: ""));

    driver.findElement(By.id("latID1")).click();
    driver.findElement(By.id("latID1")).sendKeys( ...charSequences: "37.6");
    driver.findElement(By.id("lonID1")).click();
    driver.findElement(By.id("lonID1")).sendKeys( ...charSequences: "-9.6");
    driver.findElement(By.cssSelector(".col-12:nth-child(3) > .btn")).click();
    driver.findElement(By.cssSelector("span:nth-child(1))).click();
    driver.findElement(By.cssSelector("span:nth-child(1))).click();

    {
        WebElement element = driver.findElement(By.cssSelector("span:nth-child(1)));
        Actions builder = new Actions(driver);
        builder.doubleClick(element).perform();
    }

    assertThat(driver.findElement(By.cssSelector("h3 > b")).getText(), is( value: "City: Sines"));
    assertThat(driver.findElement(By.id("latID1")).getText(), is(not( value: "37.6")));
    assertThat(driver.findElement(By.id("lonID1")).getText(), is(not( value: "-9.6")));
}
}
```

3.4 Static code analysis

[which tools/workflow was used to for static code analysis? Show and interpret the results.]
[you may add some interesting lessons learned, e.g., some code smell reported by the tool that was difficult to spot and otherwise you wouldn't address it]

4 References & resources

Project resources

- The video demo is on Git (if having trouble watching use <https://www.onlinemp4parser.com/>)
- QA dashboard:

Reference materials

As mentioned before the API used was from WeatherBit.io.

<document the key components (e.g.: libraries, API) or key references (e.g.: blog post) that were helpful and certainly would help other students pursuing a similar work>