Integrative Project Assignment

lapr2-2023-24 - version 2.0

April 8, 2024

Abstract

This document comprises the Integrative Project Assignment detailed description of the practical work to be developed within ESOFT, MATCP, MDISC, PPROG, and LAPR2 courses. The work consists of developing an IT solution to support some of the critical tasks of an organization responsible for planning and maintaining green spaces for collective use. This document briefly introduces the business' domain and sub-areas, the functional and non-functional requirements of the solution to be developed, the Integrative Project technical details, and the operating mode, i.e., the work approach.

Table 1: Version register

Version	**Description**
1.0	First version
1.1	Added Sprint1 and Acceptance Criteria
1.12	Typos and minor errors corrected
1.13	Minor grammar/language errors corrected in US03-AC1; US05-AC1; US06; US08
2.0	Added Sprint2: US09; US10; US11; US12; US13; US14, and Acceptance Criteria

Contents

1 Integrative Project

In this project, students should analyze, design and implement a computer solution to support the activity of an organization responsible for managing green spaces for collective use in predominantly urban contexts. Students must be organized in teams, and the proof-of-concept to be developed covers several critical aspects concerning the planning and maintenance of green spaces (such as gardens or parks), namely: multidisciplinary team management; allocation of teams to green spaces; fleet, machines and other equipment management; optimization of irrigation and/or lighting systems; production of statistical indicators that allow measuring the performance of the activity.

Following the good practices learned throughout the degree, and in particular in Software Engineering (ESOFT), Programming Paradigms (PPROG), Computational Mathematics (MATCP), Discrete Mathematics (MDISC) and Laboratory-Project II (LAPR2) courses, this project implies applying an iterative and incremental development process. Therefore, an agile methodology based on SCRUM should be used to manage teamwork in each four-week SPRINT.

The software solution to be developed must be composed of a set of applications in Java that must accomplish the requirements. In order to increase the solution maintainability, and respect good software development practices, the implementation must follow a TDD (Test-Driven Development) approach.

2 Problem Statement: Description

The green spaces for collective use, often called "gardens" and "parks", are fundamental for people's quality of life, especially in urban or semi-urban contexts. Currently, their need, location, and dimensions are stipulated in the general law and are an integral part of Municipal Master Plans. Contact with nature is an essential element for the well-being of the population in general. This contact was natural and obvious until the Industrial Revolution, after which a significant migration of populations from rural to urban areas occurred. According to a 2022 UN report, at the current rate, it is expected that the concentration of the world's population in urban areas will increase from 56% to 68% by the year 2050, which in urban contexts translates into an increase of 2.2 thousand million people. The Portuguese reality does not differ much from the global context.

In democratic and liberal systems, such as the Portuguese, citizens naturally demand the existence of green spaces in both quantity and quality suitable for the size of the population. Therefore, the proper management of these spaces is of great importance.

Green spaces for collective use can vary significantly in dimensions and available amenities. They may range from small landscaped areas, parks with trees and some amenities like benches or playgrounds, to parks with multiple hectares (e.g., in Porto, there are the *Parque da Cidade* - City Park - the *Parque Oriental* - the Oriental Park), wooded areas, lakes, and various facilities and installations.

MusgoSublime (MS) is an organization dedicated to the planning, construction and maintenance of green spaces for collective use in their multiple dimensions, namely: plant material (e.g. flowers, shrubs, trees); urban furniture (e.g. benches, tables, gymnastics equipment); irrigation systems and drinking fountains; lighting systems and the respective power supply; rainwater conduction and drainage systems. In the context of the current project MS will provide the requirements for the proof-of-concept to be developed.

2.1 Green Spaces for Collective Use

The green spaces for collective use managed by MS can significantly vary in size and installed equipment:

- Garden - garden space with or without trees with little or no equipment (may have a basic irrigation system or/and benches);
- Medium-sized park - green space with a few hundred or thousands of square meters with a wooded garden area, it includes some infrastructures such as toilets, drinking fountains, irrigation system, lighting, children's playground (for example, *Quinta do Covelo*, *Jardim d'Arca de Água*);
- Large-sized park - multi-function space with diverse garden spaces, and woods, including varied equipment and services (for example, *Parque da Cidade*).

2.2 Collaborators, tasks, and teams

MS has a wide range of employees who carry out numerous tasks regarding the design and management of green spaces. Some job examples are designer, budget manager, gardener, electrician or bricklayer. Thus, an employee has a main occupation (job) and a set of skills that enables him to take on certain tasks and responsibilities, for example, driving different types of vehicles (e.g. light, or heavy), operating machines such as backhoes or tractors, tree pruning, application of agriculture phytopharmaceuticals.

Tasks are carried out on an occasional or regular basis, in one or more green spaces, for example: tree pruning, installation of an irrigation system, and installation of a lighting system.

Teams are temporary associations of employees who will carry out a determined set of tasks in one or more green spaces. When creating multipurpose teams, the number of members and the set of skills that must be covered are crucial.

2.3 Vehicles, machines, and equipment

Vehicles are needed to carry out the tasks assigned to the teams and to transport machines and equipment. This type of vehicle may be only for passengers or mixed, light or heavy, open box or closed vans or trucks.

As for machines, MS has tractors, backhoe loaders, and rotating machines, lawnmowers, among others. The equipment can be greatly diverse,

such as sprayers, lifting platforms, chainsaws, brush cutters, blowers, ladders, cisterns and the various elements that can be attached to tractors, such as disc harrows, weeders, aerators and scarifiers.

2.4 Agenda

The Agenda is a crucial mechanism for planning the week's work. Each entry in the Agenda defines a task (that was previously included in the to-do list). A team will carry out that task in a green space at a certain time interval on a specific date. Comparatively analyzing the Agenda entries and the pending tasks (to-do list) allows you to evaluate the work still to be done, the busyness of the week, and the work performed by a team in a green space at a determined time interval and on a specific date.

2.5 Green Spaces User Portal

The green spaces management aims (within the available budget) to design, build and maintain parks and gardens that meet the requirements of the common citizen who wants to be informed. With this in mind, the objective is to develop a Portal in which parks and garden users can post comments, and report faults and malfunctions of equipment.

2.6 System Users

This system may potentially be used by multiple users, namely:

- Human Resources Manager (HRM) - a person who manages human resources and defines teams based on the needs of ongoing projects and on the employees' skills.
- Vehicle and Equipment Fleet Manager (VFM) – a person who manages the fleet park, the machines, equipment and vehicles, ensuring their good condition and assigning them to the tasks to be carried out.
- Collaborator – a person who is an employee in the organization and carries out design, construction and/or maintenance tasks for green areas, depending on their skills.
- Green Spaces Manager (GSM) - the person responsible for managing the green spaces in charge of the organization.

- Green Spaces User (GSU) - a person who uses the green spaces managed by the organization and who can, through the Portal, make comments or report faults in parks and gardens on the Portal.
- Software Quality Assessment Team Manager (QAM) - a person who manage the Software Quality Assessment Team and its process.

3 Minimal Viable Product (PVM)

The purpose of this project is to develop a Minimal Viable Product iteratively and incrementally; therefore the work is divided into three Sprints:

- Sprint 1 – Weeks 3 to 6 – from 4/March to 7/April
- Sprint 2 – Weeks 7 to 10 – from 8/April to 12/May
- Sprint 3 – Weeks 11 to 14 – from 13/May to 9/June

A description of the PVM is provided for each sprint. Teams must follow the user stories (US) provided and consider their interconnections and respective dependencies and, at the end of each Sprint, each team must be able to meet the specified requirements. Teams must be able to add USs to the backlog, size them appropriately, and distribute them across team members.

3.1 Sprint 1

This Sprint targets developing the following US (Requirement Engineering and Analysis):

- US01 - As a Human Resources Manager (HRM), I want to register skills that a collaborator may have.
  - AC1: A skill name can't have special characters or digits.
- US02 - As an HRM, I want to register a job that a collaborator needs to have.
  - AC1: A job name can't have special characters or digits.
- US03 - As an HRM, I want to register a collaborator with a job and fundamental characteristics.

  - AC1: name, birth date, admission date, address, contact info (mobile and email), taxpayer number, ID doc type, and respective number should be provided by the HRM. The taxpayer identification number and the citizen card number should be valid.

- US04 - As an HRM, I want to assign one or more skills to a collaborator.
- US05 - As an HRM, I want to generate a team proposal automatically.
  - AC1: The max and minimum team size and the set of skills must be supplied by the HRM, like in the following example:

    `4; 3; <tree pruner; tree pruner; tree pruner; light vehicle licence>`

- US06 - As a VFM, I wish to register a vehicle including Brand, Model, Type, Tare Weight, Gross Weight, Current Km, Register Date, Acquisition Date, and Maintenance/Check-up Frequency (in km).
- US07 - As a VFM, I wish to register a vehicle's maintenance.
- US08 - As a VFM, I want the system to produce a list (report) of vehicles needing maintenance.
  - AC1: The report should have the data concerning the vehicle description (Plate, Brand, Model and Current Kms) and the Checkup related data, like the following example:

Plate	Brand	Model	Curr.Kms	Freq	Last	Next
10-10-QR	Ford	Focus	43124	15000	41152	56152

For Sprint 1 (aka Sprint A), regarding the Requirements Engineering activity:

- teams with 4 or more students enrolled in ESOFT must elaborate all user stories;
- teams with 3 or fewer students enrolled in ESOFT must only elaborate user stories related to "Collaborators, tasks and teams" (i.e. US01 to US05).

3.2 Sprint 2

3.2.1 Teams and Vehicle Fleet Management

The user stories elaborated in Sprint 1, should now follow the Software Engineering process and proceed to Design and Implementation phases.

3.2.2 KPIs and Statistical Analysis

Managing public green spaces efficiently implies considering some KPI (key performance indicator) like: water or energy consumption, most used pieces of equipment, and park users' profile by age, for instance. The best practices concerning Statistical Analysis should be considered in the elaboration of US09 to US11.

- US09 - As a GSM, I want to know the exact costs referring to water consumption of specific green space so that I may manage these expenses efficiently. Therefore, within this US, the aim is to carry out a statistical analysis concerning the water consumption costs in all parks. The "WaterUsed.csv" file provide the necessary data to carry out the study. This file records daily water consumption (in m^3) since the day each park opened. The amount paid for water is 0.7 €/m^3, up to a consumption of 50 m^3, with a fee of 15% added for higher consumption levels.

  The data file contains records of the following information: "Park Identification", "Year", "Month", "Day", "Consumption". Consider this data in order to obtain the following outcomes:

  - Barplot representing monthly water consumption, as a result of the following specifications given by the user: time period (StartMonth, EndMonth) and park identification.
  - Average of monthly costs related to water consumption as a result of the following specifications given by the user: number of parks to be analyzed, and park identification.
  - Consider the water consumption of every day that is recorded. The aim is to analyze and compare statistical indicators between the park with the highest and lowest water consumption. For these two parks, perform the following tasks and compare results:
    * Calculate the mean, median, standard deviation, and the coefficient of skewness;
    * Build relative and absolute frequency tables (classified data), considering 5 classes;
    * Check if the data has outliers, using the outlier definition as values that deviate from the median by more than 1.5 times the interquartile range;
    * Graphically represent data through histograms with 10 classes.

- US10 - As a GSM, I want to know which piece(s) of equipment is/are used in each day so that I can understand the users' preferences. Consider that the park has the following equipment: walking paths, children's playground, picnic area, and exercise machines (gymnastics equipment). At the park exit there is an electronic device with a list of all the equipment, in which the user(s) must indicate the equipment they used that day.

  In the file "EquipmentUsed.csv" the choices of 1000 users are recorded. Make a pie chart representing, in percentage, the use of each piece of equipment.

- US11 - As a GSM, I want to be able to collect data from the user portal about the use of the park, so that I may understand the use of the park by different age groups. To analyse the use of the park by age groups, a three-question survey was inserted in the user portal:

Question	**Answer type**
Age range	1 - Child (up to 15 years old) 2 - Adult (between 16 and 65 years old) 3 - Senior (over 65 years old)
Would you recommend the park to others?	Y/N
How many times do you visit the park per month?	Numeric

  The obtained responses are recorded in the "Inquiry.csv" file.

  - Indicate the type of each of the three variables.
  - Indicate the proportion of users from each age group who would recommend the park to others.
  - Create a boxplot for each age group, regarding the monthly frequency of use of the park, and draw the main conclusions obtained from this type of graph.

In the elaboration of the US09 to US11 the following acceptance criteria will be considered:

- Programming Language: Python
- Development environment: Jupyter Notebook

- Work delivery format: A single Jupyter Notebook file, which contains all the work carried out.
- Each US must be composed of: (1) introduction (succinct and objective); (2) code and results, and (3) analysis and interpretation of the results.
- Formulas must be written in LaTeX.
- At the end of the file, you must indicate the contribution (in %) of each member of the group to the development of the work (the sum of all percentages must be 100%).

3.2.3 Planning and Building Irrigation Systems

Planning and building irrigation systems in green parks are expensive and time consuming tasks. The use of computer systems and namely powerful algorithms can save materials like pipes, reduce the time required for the planning and installation, and allow to create more efficient irrigation systems. This becomes even more relevant when considering the installation of irrigation systems in parks that are already in operation, because periods of construction prevent their normal operation.

In the first phase, a topographic survey is carried out with the aim of identifying the garden/wooded areas and existing paths in the park. A basic sketch of the result of this phase is shown in the Figure 1.i. In the next phase, based on the survey previously carried out, a collaborator specialized in irrigation systems defines the necessary water supply points. As the example shown in the Figure 1.ii. Finally, the routes between each pair of water supply points are identified and measured according to Figure 1.iii.

- US12 - As a GSM, I want to import a .csv file containing lines with:

  ```
  Water Point X, Water Point Y, Distance
  ```

  into a unique data structure.

  The set of imported lines describes all possible routes that can be opened to lay pipes between each pair of water points, and their respective installation costs (these could simply refer to the length, or to any other cost parameter).

- US13 - As a GSM, I want to apply an algorithm that returns the routes to be opened and pipes needed to be laid with a minimum accumulated cost, ensuring that all points are adequately supplied.

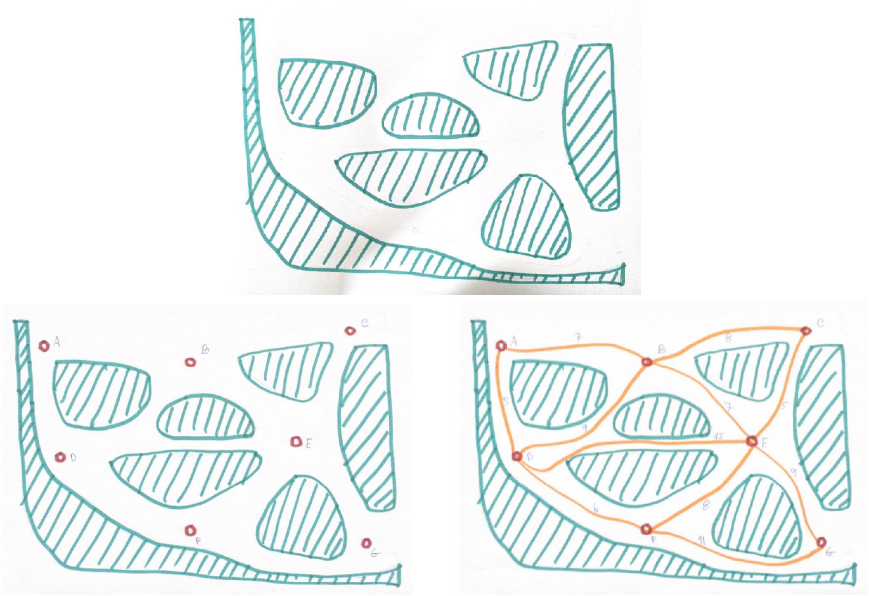

Figure 1: (i) Green Area Survey; (ii) Water Supply Points Forecast; (iii) Route Forecast and Measurement.

  - AC1: All implemented procedures must only use primitive operations, and not existing functions in JAVA libraries.

- US14 - As a QAM, I want to run tests for inputs of variable size, to observe the asymptotic behavior of the execution time of the US13 algorithm.

  - AC1: The graphic referring to the asymptotic behavior of the execution running time tests should be presented in a time unit that allows to distinguish the running times of all tested examples.

3.3 Sprint 3

3.4 Non-functional requirements

This section describes some non-functional requirements which must be considered when implementing the project.

- Business rules validation must be respected when recording and updating data.

- The class structure must be designed to allow easy maintenance and the addition of new features, following the best Object-Oriented (OO) practices.
- The application must be developed in Java Language, using the IntelliJ IDE or NetBeans. The application's graphical interface is to be developed in JavaFX 11. All those who wish to use the application must be authenticated with a password of seven alphanumeric characters, including three capital letters and two digits.
- The application documentation must be in English language.
- During the system development, the team must: (i) adopt best practices for identifying requirements, and for OO software analysis and design; (ii) adopt recognized coding standards (e.g., CamelCase); (iii) use Javadoc to generate useful documentation for Java code.
- The development team must implement unit tests for all methods, except for the methods that implement Input/Output operations. The unit tests should be implemented using the JUnit 5 framework. The JaCoCo plugin should be used to generate the coverage report.
- All the images/figures produced during the software development process should be recorded in SVG format.
- The application ought to employ object serialization to guarantee the data persistence across two successive runs.