Distribution of Deliveries to Warehouses with Trucks electrical

Request for Proposals

1 Intended Object

It is intended to develop a **prototype** for a distribution planning system for deliveries between warehouses using a fleet of electric vehicles. The system will be called ElectricGo.

The initial prototype must consist of the following modules:

- Warehouse Management
- Logistics
- Distribution planning

As it is a prototype system, it is acceptable that only some functionalities are implemented, and the functionalities implemented must be included in the proposal report.

2 General Description

The company ElectricAcme, S.A[1] . wants a system that allows it to manage its fleet of electric trucks in the distribution of goods between the various warehouses of the company.

The company has stores in a number of municipalities (Arouca; Espinho; Gondomar; Maia; Matosinhos; Oliveira de Azeméis; Paredes; Porto; Póvoa do Varzim; Santa Maria da Feira; Santo Tirso; São João da Madeira; Trofa; Vale de Cambra; Valongo; Vila do Conde; Vila Nova de Gaia) and all stores have a warehouse, where there are products to be sold later in the store.

Due to the existence of the port of Leixões, the Matosinhos store was chosen to have the main warehouse, where lots of products arrive and then go to the stores' warehouses in the various municipalities where the company has stores. This warehouse is also the company's headquarters where the Data Processing Center (CPD) is located, to which stations in all warehouses are connected.

A warehouse is characterized by:

- Warehouse identifier, eg “M01”
- Designation, eg “Maia Norte” • Address,
  eg “Av Frederico Ulrich, Zona industrial I, 4444-999” • Geographic coordinates
  (latitude and longitude)

The company gives priority to products that affect the environment as little as possible and for that reason also chose to make deliveries between the Matosinhos warehouse and the warehouses of others.

[1] fictitious company

municipalities through a fleet of electric trucks. For this, it took the decision to place fast charging systems next to the warehouse of all stores, so that, when necessary, the electric trucks can have their batteries charged.

Electric trucks have the following characteristics:

- Tare (weight of the truck unladen, ie empty): eg 7.5 tonnes
- Load Capacity (the mass that can be transported on the truck): eg 4.3 tons
- Maximum charge of the truck's electric battery pack (energy accumulated in the batteries): e.g. 80 kWh (kilo watt hour)
- Autonomy of the truck with the full load capacity (eg 4.3 tons) and with the fully charged electric batteries: e.g. 100 km
- Fast charging time for the truck's batteries (to charge the batteries from the minimum recommended electrical charge, 20%, to a default value of 80%): eg 1 hour

Every day the company will plan the necessary deliveries to the various warehouses/stores based on sales forecasts and orders placed2 .

The delivery plan thus includes the delivery list with the following information:

- Delivery identifier, eg “220909/1”
- Delivery Date (day, month, year)
- Mass of delivery (in kg, associated with the weight of the products to be delivered)
- Warehouse for delivery: store identifier
- Time to place a delivery on the truck (in minutes)
- Time to pick up the delivery from the truck (in minutes)

For example, delivery with identifier “220909/1” must be made by October 3, 2022 and has a mass of 200 kg, and must be delivered to Trofa, with the time for placing the products on the truck of 9 minutes and 12-minute truck order pick-up3 .

This delivery plan will be the basis for the fleet planning module. To this end, the company has already defined the best paths between pairs of warehouses and wants to know the best travel sequence to guarantee all deliveries and minimize various operational parameters (eg, used truck load, total distance traveled).

The information that the company has on the best paths between two warehouses is as follows:

- Identification of the departure warehouse
- Identification of the arrival warehouse
- Distance (in km)
- Time (in minutes) to cover the distance with the truck completely full, or that is, with a load of 4.3 tons
- Battery energy used to travel that distance with the truck completely full (in kWh)

[2] The planning functionality of this module is outside the scope of this prototype, being necessary just inputting delivery data.

[3] Although these times also depend on the other orders that are on the truck and the way they are placed, for the scope of this prototype it will not be about the spatial planning of placing and removing loads on the truck.

- Extra time if extra battery charging is required (this data is only different from 0 when charging the batteries to 80% previously is not enough to completely cover the section, for example for a truck that carries 4.3 tons and that you have to go from Póvoa do Varzim to Arouca)

For example, the section between Maia and Espinho with a distance of 31 km is covered by the truck in 53 minutes when the truck is completely full and uses 25 kWh of battery power.

The travel time and battery power consumed when the truck is not completely full will be less than the values indicated in a relationship that will have to do with the truck's tare weight and the load (in kg) transported4 .

Before going from one warehouse to another, we must make sure that the truck has enough charge in the batteries to make the journey, and should not arrive at it with less than 20% of the battery charge (16kWh), if the batteries are not charged. enough to do so, the batteries must be quickly charged up to 80% of their energy (64 kWh).
It is assumed that the time required for this charge is directly related to a charge from 20% to 80% of the batteries taking 1 hour, for example, if the truck batteries are at 30% then charging to 80% will take 50 minutes5 . Note, also, that this load can start to be done as soon as the truck arrives at the warehouse and simultaneously with the withdrawal of the order to the warehouse.

The company starts making deliveries with the trucks leaving the Matosinhos warehouse in the morning and the truck will travel a path going from one warehouse to another, between the warehouses it has to visit to make the deliveries, returning at the end to the Matosinhos warehouse.

At the end of the day's deliveries, the truck receives the orders for the next day and during the night the batteries undergo a slower charging process (cheaper and which saves the batteries more in terms of their lifespan) and which takes the same at 100% level.

Regarding infrastructure, the company accepts a maximum tolerable downtime (MTD) of 2h and a maximum disruption time (MTPD) of 5h. Given its business area, the infrastructure in normal operation must be in continuous operation, 7x24. For the sake of business continuity there must be a mechanism for *mirroring* the system's data to an external system.

Thus, a system similar to the one in the following figure is recommended.

[4] Note that there are other variables that affect the time and energy spent on the same section, namely the speed of the truck, but for simplicity we will not consider the impact of these other variables

[5] Simplified calculation for prototype purposes

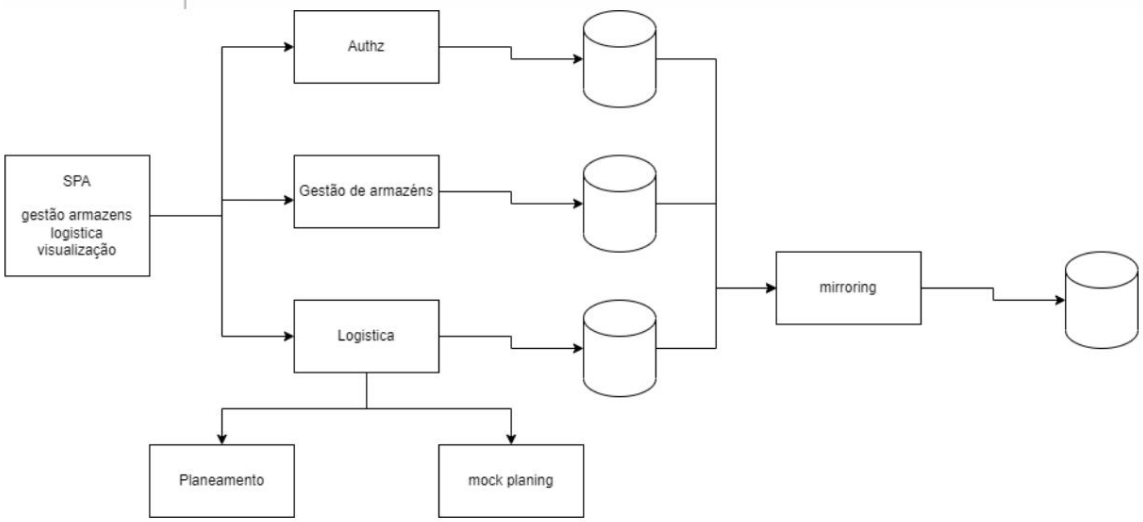

Figure 1. System overview

There will be the following types of system users:

• System Administrator – manages users and their authorizations • Warehouse Manager – manages warehouse and delivery data • Fleet Manager – manages truck data • Logistics Manager – manages route data and distribution planning

3 requirements

3.1 Sprint A 3.1.1

Warehouse Management Module 1. Warehouse

Master Data REST Service

The. Create, List and Edit Warehouse b. Create, List and Edit Delivery

3.1.2 Logistics Module 1.

Logistics Master Data REST Service a. Create, List and Edit Truck b. Create, List and Edit Route between two warehouses

3.2 Sprint B

3.2.1 User Interface Module (SPA)

1. Warehouse Management

The. As a warehouse manager I want to Create a Warehouse b. As a warehouse manager I want to Create a Delivery 2. Logistics a. As a fleet manager I want to Create a Truck b. As a logistics manager I want to create a route between two warehouses c. As a logistics manager I want to get Route Planning for 1 truck

and 1 given day

3. 3D visualization

The. As a logistics manager I intend to graphically visualize the road network in 3D. The visualization should occupy the entire useful area of the browser. Model the road network (see Tutorial).

B. As a logistics manager I want to graphically visualize the existing warehouses. Create or import the corresponding 3D models (eg OBJ, GLTF, 3DS or others).

ç. As a logistics manager I want to control the visualization. add the pan, zoom, and orbit6 camera commands .

3.2.2 Logistics Module

1. Logistics Master Data REST Service

The. Fleet planning for 1 truck and 1 given day

3.2.3 Planning module7

1. Receiving data on deliveries to be made by 1 truck and sections between warehouses:

The. can generate all possible trajectories through sequences of warehouses where deliveries must be made

B. evaluate these trajectories according to the time to complete all deliveries and return to the Matosinhos base warehouse and choose the solution that allows the truck to return sooner

ç. increase the dimension of the problem (putting more warehouses to be visited) and verify to what extent it is feasible to proceed in the adopted way (with a generator of all the solutions) by carrying out a study of the complexity of the problem

d. implement heuristics that can quickly generate a solution (not necessarily the best one) and evaluate the quality of these heuristics (for example, deliver to the nearest warehouse; then deliver with greater mass; combine distance for delivery with mass delivered)

3.2.4 Infrastructure

1. Continuous *build pipeline* for master data module
2. Automatic *deployment* of one of the modules via pipeline in a *cloud* environment
3. DB *Deployment* in a *cloud* environment or in the DEI *Cloud*
4. *Deployment* of 1 (one) of the modules in the DEI VM, with IP *filtering* configuration to only allow access from DEI network IPs
5. As a client of the project, I intend the *Business Impact Analysis* (BIA) and the risk matrix

3.3 Sprint C

3.3.1 User Interface Module (SPA)

1. Authentication

The. As an administrator I want to create a user account indicating a telephone number for direct contact as well as the type of user

B. As an administrator I want to cancel an account by anonymizing the personal data that has been collected

ç. As a user, I want to authenticate myself in the application via SSO (eg AzureAD, Google, Facebook)

[6] Suggestion: right mouse button – pan; mouse wheel – zoom; left mouse button – orbit

[7] Must be developed in Prolog

2. Logistics

The. As a logistics manager, I want to obtain Route Planning for the entire fleet and visualization of the best solution using genetic algorithm

3. 3D visualization

The. As a logistics manager I want to graphically visualize a distribution truck. Create or import the corresponding 3D model (eg OBJ, GLTF, 3DS or other).

B. As a logistics manager, I intend to increase the realism of the graphic representation, through **adequate lighting** of the scene, contemplating at least one ambient light source and a directional light source, with shadow projection;

ç. As a logistics manager, I intend to increase the realism of the graphic representation by **mapping appropriate textures** on the objects that make up the scene.

d. As a logistics manager I intend to **interactively animate** the movement of the truck, thus allowing the visualization of the delivery plan.
User-controlled interactive movement: use four navigation keys[8] . Implement collision detection, in order to prevent the truck from exceeding the limits of the road network[9] ;

and. As a logistics manager I want to **automatically animate** the movement of the truck, thus allowing the visualization of the delivery plan.
Computer-controlled automatic movement, no need to implement collision detection.

4. As a client of the project, I want a report that, describing the solution found and considering the rules of the RGPD, specifically identifies the personal data used, as well as the purpose and basis for the processing of this personal data.

3.3.2 Logistics Module

1. Logistics Master Data REST Service

The. Fleet planning and solution persistence. Use of planning module in Prolog as a strategy and Onion architecture using injection to use mock strategy.

3.3.3 Planning module

1. As a logistics manager I want a solution to the problem using Algorithms genetics
2. As a logistics manager, I want predicates that allow the attribution of deliveries to a batch of trucks (for example, 3 trucks), assuming that the deliveries received together exceed the load capacity of the truck
3. As a client of the project, I intend to carry out a bibliographic study on the application of a of the following technologies to this problem: intelligent robotics; computer vision; machine learning.

3.3.4 Infrastructure

1. As a client of the project, I want a Disaster Recovery Plan

[8] Suggestion: 'A' key – turn to the left; 'D' key – rotate to the right; 'W' key – advance; 'S' key - back off

[9] A collision detection support tutorial will be provided

2. As a system administrator I want a BD *mirroring script* for the environment *cloud*