TQS: Product specification report

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[This report is the main source of technical documentation on the project, clarifying the functional scope and architectural choices. Provide concise, but informative content, **allowing other software engineers to understand the product**.
Tips on the expected content placed along the document are meant to be removed!
You may use English or Portuguese; do not mix.]

1 Introduction

1.1 Overview of the project

<contextualize the objectives of this project assignment in the scope of the TQS course>
<introduce your application/product: brief overview of the solution concept. What is it good for? Introduce the name of the product if it has one>

The increased adoption of electric vehicles (EVs) has introduced new infrastructure challenges, such as the fragmentation across different applications (Waze EV, PlugShare, ChargeMap) and charging networks, as well as difficulties in locating available charging stations. **PowerNest** emerges to integrate this ecosystem, offering a unified platform that simplifies station search, reservation, payment, and usage monitoring for both drivers and station operators.

With the platform, drivers can easily find nearby charging stations, book time slots, unlock chargers, and process payments seamlessly, minimizing "range anxiety" and optimizing trip planning. Station operators, on the other hand, use a centralized management dashboard to register new stations, update pricing, monitor station usage, and schedule maintenance, thus improving operational efficiency and user satisfaction.

To ensure that this solution operates safely, reliably, and efficiently, this project adopts rigorous Software Quality Assurance (SQA) practices. From defining testable requirements and user stories with clear acceptance criteria to implementing automated tests, continuous integration (CI/CD), code analysis, and security practices, our aim is to deliver a platform with high reliability, consistent performance, and an outstanding user experience.

1.2 Known limitations

<explain the known limitations, especially the features that were planned/expected but not implemented (and why…)

To be reviewed and completed by the end of the project >

1.3 References and resources

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

2 Product concept and requirements

2.1 Vision statement

<functional (black-box) description of the application: Which is the high-level/business problem being solved by your system? Which are the key features you promise to address it?>
<if needed, clarify what was planned/expected to be included but was changed to a different approach/concept >
<optional: how is your system different or similar to other well-known products?>
<optional: additional details on the process for the requirements gathering and selection (how did we developed the concept? Who helped us with the requirements? etc)>

2.2 Personas and scenarios

<“Personas are fictional people. They have names, likenesses, clothes, occupations, families, friends, pets, possessions, and so forth. They have age, gender, ethnicity, educational achievement, and socioeconomic status. They have life stories, goals and tasks. Scenarios can

be constructed around personas, but the personas come first. They are not 'agents' or 'actors' in a script, they are people. Photographs of the personas and their workplaces are created and displayed. […] It is to obtain a more powerful level of identification and engagement that enable design, development, and testing to move forward more effectively". Adapted from Grudin, J. and Pruitt, J., 2002, June. Personas, participatory design and product development: An infrastructure for engagement. In Proc. PDC (Vol. 2).
Sample personas: secção 4.1, neste artigo (open access)] >

<Develop one or more representative scenarios for each persona. You don't need to include all possible details. Pick the main scenarios, related to the core value of the system.>
<The scenarios tell the story of the Personas in their lives, doing their daily/professional activities that are relevant to find the points of contact with the system under specification.
Scenarios are somewhat similar to use cases (they have a goal and tell a story), but, unlike use cases, they capture a larger process, with activities that may not use the software. Scenarios don't required a "template", like the usual use cases description.>
Sample: secção 4.2 neste artigo (open access)] >

Persona 1: Pedro Almeida – Daily EV Driver

- **Age:** 34 years old
- **Profession:** Analyst (works in an office in the city)
- **Biography:** Pedro lives in an apartment and does not have his own garage with a charger, so he depends on public charging stations for his electric vehicle. He is a technology and sustainability enthusiast, having bought an EV to save on fuel and reduce his carbon footprint. He uses the car daily to go to work and take his children to school, making mainly urban trips.
- **Objectives with the use of the platform:** Quickly find an available charging station nearby during his daily routine; minimize the waiting time for charging; keep track of how much energy he spends and consumes per month to control his family budget. Pedro wants to use **a single, reliable platform** that helps him plan his weekly top-ups without any hassle.
- **Frustrations:** Before **PowerNest,** Pedro was frustrated by having to switch between several apps from different operators to locate an available charging station. It has happened that he has arrived at a station that was available, but when you arrive you find it out of service – a huge waste of time. In addition, he hates having to carry ID cards or register with each charging network separately. Another frustration is not being clear about the cost of recharging until he receives separate invoices later.
- **Specific needs:** Reliable real-time **information** on the availability and operation of the stations; possibility to **filter by type of connector** compatible with his car; simple interface that shows distance and estimated time to the charging point; **automated payment** in the app so he doesn't have to deal with cash or cards on the spot; and access to a **detailed history** of recharges (kWh consumed, amount paid, location and date) to monitor his monthly consumption.

Persona 2: Carla Mendes – Long Distance Traveler with EV

- **Age:** 41 years old
- **Profession:** Sales Representative (regional sales)
- **Biography:** Carla works traveling by car through several cities in the countryside, visiting clients throughout the week. She spends many hours on the road and her

electric sedan is her work tool. Because she travels to new places frequently, Carla needs to carefully plan the stops for recharging during her trips, ensuring that she will be able to reach her destinations without delays. She values punctuality in meetings and can't afford to run out of battery midway.

- **Objectives with the use of the platform: Plan efficient travel routes** considering charging points along the way; book a charging time in advance to avoid arriving at a station and finding it busy; optimize her time on the road knowing exactly where and when to stop to charge. Carla also wants to have **payment receipts** organized, as she needs to report the recharge costs for reimbursement by the company.
- **Frustrations:** Carla has already faced the situation of arriving at an electric station in an unknown city and discovering that all the points were occupied or out of operation. This forced her to wait a long time and almost caused her to miss a work appointment. She is frustrated by the lack of integration between networks: having to maintain multiple apps and registrations for different regions.
- **Specific needs: Parking space reservation function** at the charging station, to ensure that when arriving at a certain time there will be a connector available for it; estimation of the **recharging time needed** to achieve the desired autonomy, helping in planning her schedule; integration with **a navigation** system to trace the route to the chosen station; and store detailed receipts for each recharge (date, location, cost, energy) to facilitate accountability to the company.

Persona 3: Luís Fernando – Charging Station Operator

- **Age:** 52 years old
- **Profession:** Entrepreneur (owner of a small electric station business)
- **Biography:** Luís owns two fast charging stations located at strategic points in the city. He entered the EV infrastructure business when he noticed the growth of this fleet and wanted to offer a quality service to drivers, while seeking to monetize his investment in equipment. Luís is not a programmer, but he deals well with computers; He himself monitors the day-to-day operations of his stations.
- **Objectives with the use of the platform: Promote your charging stations** to reach as many drivers as possible through the unified platform; manage the **availability and prices** of his stations (for example, adjust fares during peak hours or offer loyalty discounts); update **alerts of failures or maintenance needs** in an agile way; monitor **financial and operational** performance – how many recharges are made per day, how much energy is being supplied and what is the accumulated billing. In short, Luis wants a centralized tool to **manage and optimize his stations** without complication.
- **Frustrations:** Before using **PowerNest,** Luís depended on customers to call or complain to find out that a station had a problem, which generated dissatisfaction and loss of revenue while the point was unusable. In addition, it felt "invisible" to many EV drivers, since only those who knew its station directly used it; It didn't have a broad platform to make it visible to new users.
- **Specific needs:** An intuitive **back-office** interface where he can **register new stations** and edit information (address, power, connector types, hours of operation, price per kWh); ability to **change the status** of a station (available, under maintenance, occupied) in real time, informing users.

Persona 4: Ana Rodrigues – Charging Station Maintenance Technician

- **Age:** 29 years old

- **Profession:** Electrotechnical Technician (employee of a charging infrastructure company)
- **Biography:** Ana works in the technical support team that keeps dozens of charging stations operational throughout the region. Their day-to-day task involves remotely monitoring the status of equipment and also going to the field to perform repairs or preventive maintenance. She is trained in electrical systems and also has the IT notion to deal with station management software. Ana understands that, for drivers to trust the charging network, it is crucial that the equipment is working perfectly and that any problems are resolved quickly.
- **Objectives with the use of the platform: Remotely monitor the status** of each charging station under your responsibility in one place; **notify** when a point has an error or goes offline, so that he can act before too many users are affected; put a station in **maintenance mode** via the system, preventing new users from trying to use it while it is being repaired;
- **Frustrations:** Ana's hands were tied when the old tools didn't show enough detail – sometimes a station stopped working, with clients complaining on social media. The lack of a centralized dashboard forced it to check several systems: one for the online status of the machines, the other for technical records. She also got frustrated when she needed to schedule preventive maintenance and had no way to block reservations at that time, causing conflict with a driver who arrived to load. Every minute of an inactive station without warning represented angry drivers and damage to the company's image.
- **Specific needs: Unified operations dashboard** that lists all stations and their current status (available, under maintenance, occupied); possibility to **insert notes or signs** in the stations (e.g. "maintenance scheduled today 2pm-4pm") visible both internally and to users, ensuring transparency; **technical history** of each station, including electrical data and past incidents, to aid in the analysis of recurring faults

User Stories

1. **As an electric vehicle driver, I want to search for nearby charging stations** to easily find where to recharge my car when the battery is low.
    a. **Acceptance criteria:**
        i. Since I am logged in to the app and allow access to my location, when I open the search screen I should see on an **interactive map** the available charging stations nearby, with a clear indication of which ones are **free or occupied** in real time.
        ii. The system should allow me **to filter** the stations by criteria such as connector type (e.g., CCS, Type 2), charging speed (slow/fast), and carrier network, displaying only the points that meet my preferences.
        iii. When selecting a specific station on the map or list, I must view details such as address, distance, number of spaces, power offered, fares and reviews from other users.
2. **As an electric vehicle driver, I want to book a time slot at a charging station in advance** to ensure that I will have a charging point available when I arrive, especially at peak times or long trips.
    a. **Acceptance criteria:**

        i. In the interface of the chosen station, there should be the option to **schedule a time**: I enter the desired start date and time (among the available times) and the estimated duration of the session or amount of load desired.
        ii. The system should not allow double booking at the same point/time – that is, it **prevents overbooking**. If I try to book an already busy slot, I'll receive a warning and the ability to choose another time or station.
        iii. When confirming the booking, I should receive an **immediate confirmation** with the details (station, time booked, confirmation code or QR code) and the booking should be in my history/agenda in the app.
3. **As an electric vehicle driver, I want to unlock the charger and start recharging through the app** to start charging my car hassle-free when arriving at the reserved or unoccupied station.
    a. **Acceptance criteria:**
        i. When I arrive at the station, I should be able to select my active reservation (or the desired free point) in the app and activate the **"Start Charging" function**, which remotely unlocks the connector corresponding to my space.
        ii. If I have a reservation, the system must validate that I am within the reserved time slot and, if so, allow the session to start (if I arrive too early or too late, I may need to adjust or notify unavailability). If I'm using a walk-in point, the app should check if the point is free and then release it immediately.
        iii. During the recharge, I want to see in the app the **real-time data** of the session: energy (kWh) already supplied, accumulated cost so far, and elapsed time. There should be the option to **log out** of the app when I want to finish recharging; by doing so, the charger should be locked again and my results recorded.
4. **As an electric vehicle driver, I want to track my consumption and recharge history on a personal dashboard** to understand my spending, my energy usage, and better plan my future recharges.
    a. **Acceptance criteria:**
        i. In my profile or dashboard, I should have access to a **detailed history of all charging sessions** carried out via the platform: listing date and time, location (season), duration, energy consumed (kWh) and cost paid in each session.
        ii. The system should present useful **aggregate statistics**, such as total kWh consumed in the last month, total spending on recharges in a period, average spending per session, and even how many CO_2 emissions were avoided by using electricity (an extra environmental data, if available).
        iii. I want to be able to **export or share** a report of my history (e.g. to send to the company in the case of enterprise use) and filter the information by period (last week, 6 months, current year, etc.). In addition, associated payment information (receipts) must be available for each top-up.
5. **As a charging station operator, I want to register a new station on the platform** so that it is visible to drivers and I can start offering my charging services through the unified system.
    a. **Acceptance criteria:**

   i. The platform must provide a **registration interface** where I enter the details of my station: location (address and GPS coordinates), number of charging points, types of connectors available at each point, power (kW) of each charger, operating hours and tariff (price per kWh or per time).
   ii. After submitting this information, the system must **validate basic data** (e.g. check that the coordinates match the address provided, that all required fields have been filled in correctly). There may be an approval process by the **PowerNest team,** if necessary, but once approved, the station should appear to all users in searches and maps.
   iii. As an operator, I should be able to later **edit** the station data when needed (e.g. change the kWh price or update the availability of a connector) through the same portal, with the changes reflected to drivers in real-time.

6. **As a maintenance technician, I want to mark a station as "under maintenance" temporarily** so that drivers are informed of unavailability during repairs, avoiding attempts to use it while working on site.
   a. **Acceptance criteria:**
      i. From the admin panel, I should be able to **change the status** of a specific charging point (or the entire station) to "Maintenance" or "Unavailable" by adding, if possible, an explanatory note (e.g., *"Preventive maintenance from 2 pm to 4 pm today").*
      ii. When the maintenance status is activated, drivers viewing that station in the app should see it clearly indicated as unavailable for that period (for example, a different icon or "On Maintenance" message) and **prevent new** reservations or logins for the duration of the maintenance.
      iii. Any driver who has an upcoming active booking at that station during the scheduled period should receive an **immediate warning/alert** about the conflict. (E.g.: "Your 3pm reservation has been canceled due to maintenance. Please reschedule at another station.") – This criterion ensures that no one is caught by surprise. As soon as I, as a technician, resolve the issue and clock in as available again, the system resumes its normal use.

7. **As an electric vehicle driver, I want to pay for the recharge directly through the app** to complete the process in a practical way and receive receipts automatically, without needing additional interactions.
   a. **Acceptance criteria:**
      i. At the end of a charging session, the app must calculate the **amount to pay** based on the station rate (per kWh or minute, as defined) and present a summary of the charge before confirming the payment.
      ii. The system must support **integrated payment methods**: for example, use of a previously registered credit card, account debit, or digital wallet (such as Apple Pay/Google Pay, if applicable). The driver must be able to choose or register the payment method of their choice only once, and then the next transactions occur automatically using that saved method.
      iii. After the payment is successfully processed, the user must receive a **digital receipt** in the app itself, containing details of the transaction: station, date/time, energy consumed, amount charged, and payment

method used. If the payment fails for some reason, the system must notify the user immediately and offer alternatives (try another method, or forward payment at the station if available).

2.3 Project epics and priorities

[Apresentar um plano indicativo para a implementação incremental da solução ao longo de várias iterações/releases, explicando as funcionalidades a atingir por *epics*]

2.3.1 Iteration 2

1. **EP01 - Station Discovery & Filtering**
   Search nearby stations on a map, filter by connector/speed/network, see real-time availability.
2. **EP02 - Booking & Reservation Management**
   Booking interface with time slot selection, conflict detection, reservation confirmation.

2.3.2 Iteration 3

1. **EP03 - Charging Session Execution**
   Unlock charger, validate time, show real-time charging data, stop charging session.
2. **EP04 - Station Registration & Editing**
   Operators can register/edit stations with required details.
3. **EP05 - Maintenance Mode & Availability**
   Maintenance tech can mark stations as under maintenance, notify users, and restore availability.

2.3.3 Iteration 4

1. **EP06 - Consumption History & Dashboard**
   Charging session history, export, dashboard with stats.
2. **EP07 - In-App Payment & Receipt**
   Payment processing, stored payment methods, receipts.

3 Domain model

<which information concepts will be managed in this domain? How are they related?>
<use a logical model (UML classes) to explain the concepts of the domain and their attributes, not a entity-relationship relational database model>

4 Architecture notebook

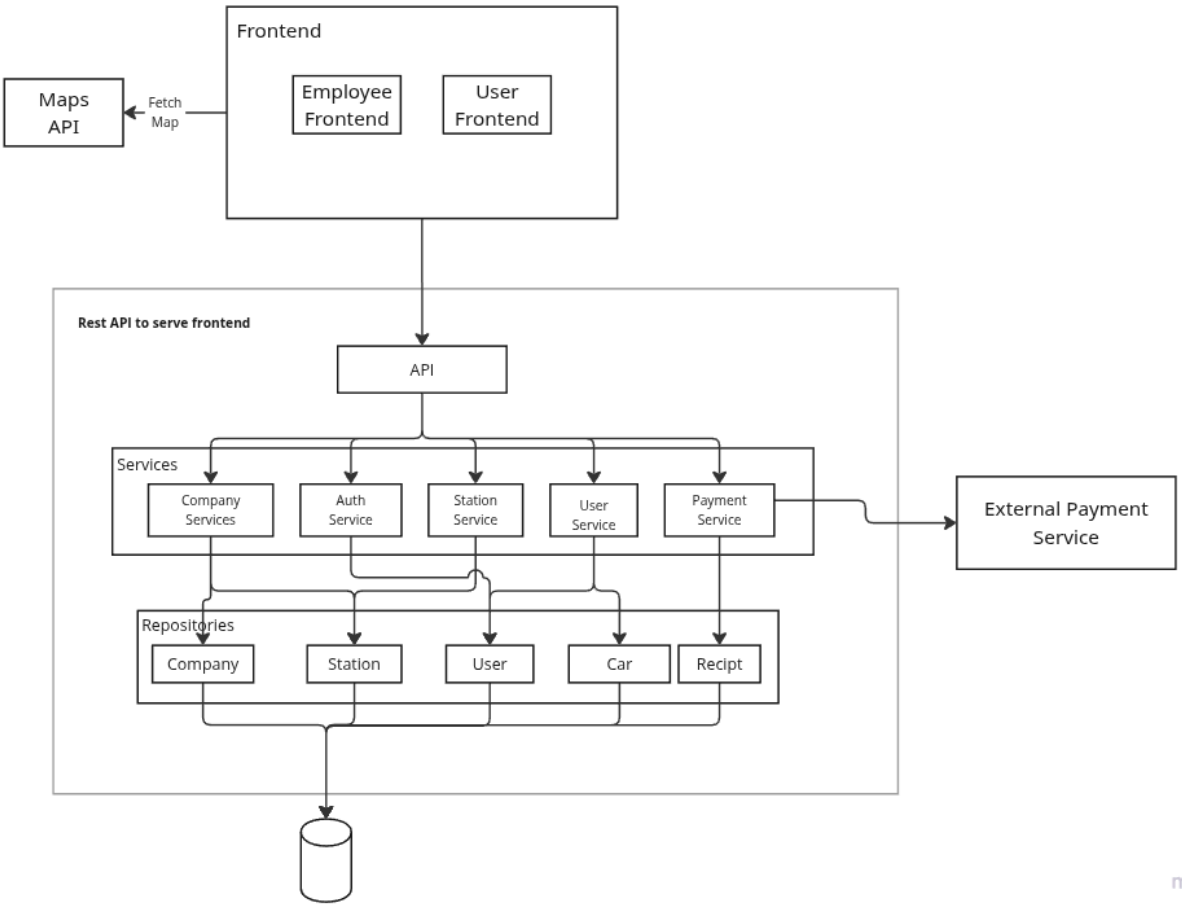
4.1 Key requirements and constrains

<**Identify issues that will drive the choices for the architecture** such as: Are there hardware dependencies that should be isolated from the rest of the system? Does the system need to function efficiently under unusual conditions? Are there integrations with external systems? Is the system to be offered in different user-interfacing platforms (web, mobile devices, big screens,…)? For a more systematical approach:

- Note the collection of Architectural Characteristics the software architect should be aware
- Identify architectural characteristics that are relevant for your project (will drive the key design decisions). Note the case study and the explicit characteristics related to users and extensibility. This will support later non-functional tests.

4.2 Architecture view

→ Discuss architecture planned for the software solution: what are the main building blocks? include a diagram (a logical view, such as a package or block diagram). Avoid implementation technology or deployment references, but protocols/standards can be included.
→ refer to the architecture style applied, if any
 explain how the identified modules will interact. Use a sequence diagram to clarify the interactions along time, when needed
→ discuss more advanced app design issues: integration with Internet-based external services, data synchronization strategy, distributed workflows, push notifications mechanism, distribution of updates to distributed devices, etc.>



4.3 Deployment view

[Explicar a organização prevista da solução em termos configuração de produção (*deployment*). Anotar, no diagrama, as tecnologias de implementação, e.g.: colocar o simbolo do PostgreSQL na Base de dados,…]. Indicar a existência de containers (Docker), endereços IP e portos,...
Esta parte será completada quando houver efetivamente deployments

5 API for developers

[Explicar genericamente a organização da API e coleções principaus. Os detalhes/documentação dos métodos devem ficar numa solução *hosted* de documentação de APIs, como o Swagger, Postman documentation, ou incluída no próprio desenvolvimento (e.g.: maven site)
 Be sure to use best practices for REST Api design. Keep minda REST API applies a resource-oriented design (APIs should be designed around resources, which are the key entities your application exposes, not actions)