FACULDADE DE ENGENHARIA DA UNIVERSIDADE DO PORTO

LuSiTa Mid-term Report

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GlowTech

Systems Engineering

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March 31, 2023

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Abbreviatures

GPIO	General Purpose Input/Output
HTTP	Hypertext Transfer Protocol
IoT	Internet of Things
LED	Light Emitting Diode
MQTT	Message Queuing Telemetry Transport
PCB	Printed Circuit Board
WBS	Work Breakdown Structure
Wi-Fi	Wireless Fidelity

Chapter 1

Introduction

1.1 The Project

GlowTech is working towards creating a portable light, LuSiTa, that can track the electricity market value and change its colour depending on the current price. LuSiTa is a smart lamp designed to help houses and companies towards saving money on electricity.

This lamp can be adapted by the user in order to be suitable for every house or company, once it can be adjusted to your energy tariff.

1.2 Team and responsibilities

At GlowTech there are conditions for controlling the performance of the duties required of each employee.

The company has an internal performance and productivity control so that the hours of service are the most productive and with the intention of not forcing our workers to run out of time roundly, increasing both their motivation and the company's earnings.

In terms of working time, the company maps the working time of each employee and the time that ideally the respective task should take, to balance the worker's efficiency and effort.

With regard to customer support and satisfaction, a balance of the time taken to carry out each requested task is made, how satisfactory the performed task was and how much time was delivered. This contributes to understanding how the task is being accomplished, both as a team and individually.

Chapter 2

Team's organizational structure

The success of any project is heavily dependent on the team responsible for its execution. This chapter focuses on the organizational structure of the team at GlowTech.

The team structure is designed to ensure efficient communication, collaboration, and accountability. Each team member reports to their respective department's Director, who reports to the Project director, who reports to the General Director. The directors are listed as follows:

- **General Director**: Tomás de Oliveira Cadete
- **Product Director**: Sara Beatriz Moreira Alves de Carvalho
- **Quality Director**: Francisco Monteiro Riesenberger
- **Information and Documentation Director**: Maria Carla Padrão Cruz Rehbein Pinheiro
- **Project Director**: Tomás Henrique Campos Ferreira Prior
- **Director of Automation**: António Pan
- **Director of Energy**: José Luís Mota Pacheco de Oliveira Monteiro
- **Director of Telecommunication**: Alexandre Araújo Pires Mourão

2.1 Directors

2.1.1 General Director

The General Director (GD) is responsible for defining the project goal, planning tasks, and their due dates. He manages the company, allocating available resources and leading the work teams in order to have the best results possible. He/she must be present in every general team meeting and transmit relevant information to the Project Monitor.

This Director delegates and supervises tasks being developed, ensuring a good work environment and relationships between teams and employees. He/she/them is responsible for the overall achievements of the company.

2.1.2 Product Director

The Product Director (PD) is in charge of the product's design, and its specifications and requirements. She manages the budget for each project and decides the most economically smart option for the product's components. Therefore, the PD is responsible for elaborating the product's datasheet.

The PD is also the one whole presents the product to potential clients.

2.1.3 Quality Director

The Quality Director (QD) defines the quality management model and the operating rules of the team. He also defines how the information and documentation system is organized.

The QD decides on the internal product quality requirements and evaluates the services provided by each worker (peer evaluation).

This director also interacts with internal and external clients, in order to infer the quality of the provided services.

2.1.4 Information and Documentation Director

The Information and Documentation Director (IDD) manages the internal communication network of the team. She organizes the team's document reports and the managing software of the project.

This director also defines the documentation templates, runs the communication and presentation platforms of the project, and creates the product publicity material.

2.1.5 Project Director

Planes and controls the development and execution of the product. He/she/them defines tasks to be given to the Specialty Teams and inquires if the previous ones have been finished, therefore adjusting the project schedule.

This director reports to the General Director about problems related to the management of the team that may appear, communicates with the Product Director about technical and financial aspects of the product and interacts with the Quality Director to discuss the performance of the Specialty Teams.

2.1.6 Director of Specialty

The Director of Specialty is responsible for the product's technical characteristics of said Specialty. He/she/they are in charge of searching for the components and technical solutions of the product, considering their price and functionalities, and reporting them to the Product and Project Directors.

This director also partakes in the testing and approval of the product in its different stages of development.

Chapter 3

Risk management

Risk management is an important aspect the team must deal with throughout the execution of the project. Risk management helps to predict possible negative outcomes and apply solutions to overcome said problems. Therefore, the team must monitor regularly the status of each risk and make changes as necessary. It is also very important to communicate the risks regularly to the team, to create awareness and to implement the plans developed against them.

Even though the project is still in an initial phase, during the making of LuSiTa, the team had to face some standoffs. To overcome them, the Company's Quality Manual was consulted in order to follow set protocols and have successful outcomes.

The problems the team encountered are stated below:

• **A team member missed the weekly meeting**

Weekly meetings are used to check the progress of the work being done by each member, discuss the next steps and solutions to the project and assert tasks. Missing a meeting means that the member was not informed of the decisions taken and what his/her/their tasks for the week will be.

Therefore, to prevent misinformation the Documentation Director is in charge of writing Minutes, which are uploaded to the team's GitHub repository, for every meeting, stating the bullet points for that gathering, what was discussed and the decisions that were taken. Furthermore, the Project Director allocates tasks using the platform ClickUp, so that everyone is informed of their own and other members' tasks.

According to the Quality Manual . . .

• **A team member could not complete his/her/their work for the week**

Not matching weekly deadlines is a big problem while doing a project, especially if that specific task is essential to complete a file for delivery.

In this situation, the team predicts to allocate that task (or parts of it) to another member. The member should be chosen considering if he/she/they have enough time to complete it and it won't interfere with previous work, and if the member is informed of the topic the task covers and they can execute it.

• **A team member resigns from the team**

An employer that ’resigns’ is a major issue because, similarly to the previous topic, there will be a team member that cannot meet scheduled deadlines and, furthermore, the team cannot count on that member to do future work.

The approach taken is similar to the previous risk as well, where tasks that were already allocated will be given to other members, and, in this case, the internal teams of the Company (Departments) can be reformulated in case of a shortage of employees, meaning a member from another team that feels comfortable doing a task not related to his/her/their department can be allocated to do that work.

The measures of risk management stated previously were successfully implemented, and the team suffered little impact from its occurrence.

Beyond these risks, there are other ones that the team predicts may happen. With this thought, it is essential to state the following possible problems that may arise, so alternative plans can be defined with enough time and a cool head, and not when chaos has already been installed.

• Component not arriving at the scheduled time

Ordering components online is always taken with a grain of salt. In one way it is very practical and efficient, on the other hand, problems may arise, like the product not arriving on time (or at all).

If this were to happen, the team should look for another supplier and order the missing component. In the meantime, the members that are dependent on that part to complete their task should either complete another task allocated to them, look for a new task that is necessary and has not been allocated yet, or help other members complete their work. This way, the workflow can continue to evolve and the member(s) affected can continue to be efficient in the company.

• A broken or useless component

Like the above problem, an issue with components is of ultimate importance and must be dealt with as soon as possible.

If a component breaks, the members that have tasks dependent on that component should follow the same plan as the precious risk mentioned and work on other tasks (check the previous topic),

In case a component that was ordered is stated as useless, the member that had previously planned to work with it should inform the Product Director of the occurrence and look for a useful part or discard that item completely.

• Not being able to comply with the plan

At the beginning of the project, the Project Director designed a plan for the different stages of it. This risk may be due to all the above problems and requires great flexibility and a good strategy from all team members. Therefore, the team should reunite and try to restructure a new plan to meet the project goals.

• Design issues

One of the stages of the project is the design. The design of the lamp must be compelling to the client, allowing at the same time to reach all components inside in case of malfunctioning.

Thus, the material of the lamp should be the least damaging to the environment possible, and still be resistant to damage.

If at any point in the development of the design of the lamp, the lamp does not meet the mentioned requisites above, that design should be aborted and the members responsible for should develop another one that overcomes the encountered issues. This should be done sooner, rather than later, in order to save as much time as possible.

• **Budget overrun** Budget overrun is a major problem when working on a project, as it is easy to spend more than planned. To avoid this, the Product Director discusses what is to be bought with all members and delivers tasks in order to find the best quality-price items. Furthermore, all items that are bought are listed in an account book, so the budget is closely supervised.

• **Internal conflict in the team**

In the world of engineering, dealing with people is a 'must'. Therefore, issues between team members may arise. With that said, the Quality Manual of Glowtech Company clearly states that members should make an effort to 'listen carefully and try to understand the point of view of other team members to avoid conflicts and find solutions to problems' and 'always try to focus on the problem and not letting the conflict turn personal or emotional'. These are measures to prevent conflicts between employees, however, if conflicts happen, the person in question must 'consider getting help from a mediator, like GD or QD, or a person who can give a neutral opinion, to help resolve the conflict'.

• **Miscommunication/lack of communication**

As addressed in the previous topic, all team members should follow the Company politics in order to have a good work environment. In order to avoid miscommunication, all important decisions are written in official documents, like Minutes for example, or via the team's WhatsApp chat where the members can develop and discuss what is being transmitted to them. In case a topic is not clear to anyone, that person should ask for further clarification until the message is well understood.

• **A member doesn't like the task given to him/her/their.**

Working on a project includes doing many different tasks. Some may be a bit boring and the team member allocated to that task may not enjoy doing it. That member should keep an open mind and remember that all tasks are important in order to have the best product possible.

Mental stress plays a big part in the performance of the team and also in the way the members communicate and relate with each other. This factor can influence the occurrence of most of the mentioned risks. In order to acquire risks associated with mental stress, a survey was created with the title " Satisfaction Survey".

Among various questions, the most relevant are presented below:

• How have you been doing?

• What is your current stress level?

• How much workload does this project impose on you?

• Do you think you can expose your opinion on the meetings?

- Have you ever felt like someone didn't take your opinion into consideration?
- Do you feel that your supervisor is fair, supportive, and invested in your growth?

After analyzing the data from this survey, the anonymous answers received were, in general, positive. Therefore it was concluded that the team is doing well in terms of mental health and there are no issues to be worried about for the time being.

In the future, more surveys regarding mental and work health will be made, in order to acquire the well-being of the team and as a form of taking action, in case some members need more care and attention.

Chapter 4

System requirements

The success of any project depends on the ability of the team to clearly define and meet the system requirements. In the case of the LuSiTa project, the system requirements serve as a critical guide for the development of the smart lamp. These requirements define the functionalities, features, and characteristics that the lamp should have, and they are essential in ensuring that the final product meets the needs of the target users.

This chapter presents the list of system requirements that the team has identified for the LuSiTa project. The requirements are listed in a table format, which outlines the functional and non-functional requirements that must be met by the final product.

MR	Requirements	Justification	P	F/NF
1, 3	1. System will implement colour-changing functionality: The lamp will change its colour based on the current price of electricity.	This functionality will give users information on the current price of electricity by associating the price to the colours.	H	F
2, 3, 4	2. System will provide data display: The lamp will have a display that shows data about electricity prices, pricing schedules and lamp function modes.	This functionality provides an interface that shows the user lots of relevant data.	H	F
1, 7	3. System can adjust brightness: The lamp should have adjustable brightness settings that allow users to customize the level of illumination.	Users can adjust the brightness as they wish.	M	F
8	4. Compatibility: The lamp should be designed to work with standard electrical outlets.	Compatibility is essential to let the system work correctly.	H	NF

Continued on next page

Table 4.0: (Continued)

1, 9	5. Energy Efficiency: The lamp should use low-power LED technology to reduce energy consumption.	Reducing energy consumption is important to help users save money, resulting in a longer-lasting battery.	H	NF
3	6. Wireless Connectivity: The lamp should be able to receive data and be configured wirelessly	This would improve user friendliness and configurability of the lamp.	H	F
2, 4	7. Automated Scheduling: The lamp should have an automated scheduling feature, allowing users to set it to turn on and off at specific times.	An automated scheduling can help users to save energy consumption.	M	F
10	8. Low Maintenance: The lamp should be designed for low maintenance, with minimal cleaning and maintenance required to keep it working properly.	Low maintenance helps users to save some work.	M	NF
2, 4, 11	9. Intuitive User Interface: The lamp should have an intuitive user interface that is easy to navigate and use, even for those with limited technical knowledge.	User interface should be intuitive so everybody can use it easily.	H	NF
3, 4	10. Connectable to a configurable database with information about the electricity cost with data from previous and future prices.	This would let the user prepare for future prices and compare them with past values.	H	NF
3, 4	11. Access point connectivity to configure the lamp's wifi with the support of a third-party app.	This functionality provides users with an app to configure the lamp.	M	F
1	12. The lamp should be highly portable, lightweight and small.	Users can move the lamp to wherever they want.	H	NF
2	13. A countdown timer to show the next update.	System will provide a countdown timer so users can know when the next update will be.	L	F

Continued on next page

Table 4.0: (Continued)

5	14. The commercial price can not exceed 50 euros (counting profit).	The commercial price can not exceed 50 euros so it is accessible to anyone.	H	NF
11	15. Alert the user of low battery level.	The system will alert the user that the battery is low, so the user can charge it beforehand.	M	F
4, 11	16. The system should have different tariffs and configurable time schedules.	This makes the system compatible with any type of standard tariff, with little user input.	H	F
8	17. The lamp should be rechargeable. The process to recharge should be to simply connect a charger to the lamp.	No rechargeable system can help the user to save money.	M	NF
1, 12	18. The lamp shell should not be made out of any brittle material (glass, for example) that could be easily damaged in transport.	Brittle material can break easily and be dangerous for the user.	H	NF
3, 13	19. The lamp should have a simple, mechanical on-off switch.	This improves user friendliness and allows for long periods without usage and consumption.	M	NF
11	20. User-defined thresholds: Allow users to set their own price thresholds for when the lamp should change color. This gives users more control over the lamp's response to electricity prices.	This functionality will allow users to associate the colour to the price as they prefer.	M	F
11	21. The lamp should have a mode that shows what sources the energy is coming from. Each energy source would have a colour associated with it.	The user will be informed of what sources the energy is coming from, so the user can decide to use it or not.	L	F
4, 11	22. Customizable notifications: Allows users to set up custom notifications for electricity price changes when prices exceed a certain threshold.	The notifications can alert the user of price changes in electricity.	L	F

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Table 4.0: (Continued)

1	23. The system could have different colour gradients. There are different colours of grid consumption in a day: peak time, standard consumption time, and lower-priced time (which is the best time for using high-consumption devices).	This functionality will inform users which period of grid consumption of the day is.	L	F
4	24. The database should store previous (or following) energy prices so the user can check the actual values at will.	If the user wants to check previous energy prices, it can be checked in the database.	L	F
3, 4	25. Depending on the mode (tariff) of the lamp, there will be a different refresh rate, different resolution and different prediction time span.	This functionality will provide the user with the price of the moment, according to the tariff.	H	F
1	26. To provide mobility the lamp should function without being connected to an outlet for 6 hours.	The lamp should last for 6 hours without being recharged, to provide mobility without worrying that the battery will run out.	H	NF

Chapter 5

Systems´s concept

5.1 System breakdown structure

As it is described in LuSiTa System´s concept, our system's main sections[2][4], level 0, are the lamp and the Database, that can be considered part of the product while its subcomponents are better defined as a process.

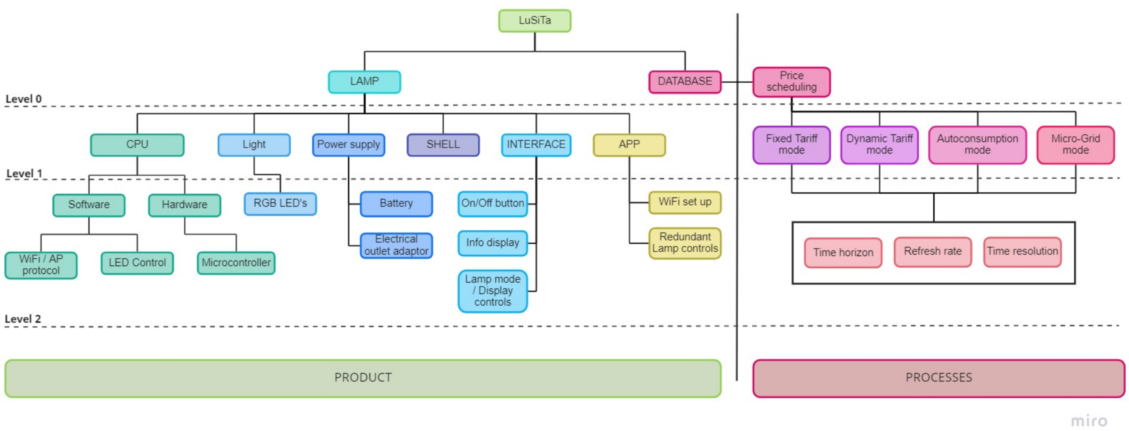


Figure 5.1: System's structure diagram

Regarding level 1 subsystems, most are self-explanatory. The shell is just the physical casing for the lamp, while the app (smartphone app) is an external feature (on the user's smartphone) that allows him/her/they to interact with the lamp. This app will not be constructed by us, but it will most likely be a third-party app, designed for IoT purposes.

With respect to level 2 subsystems, again most are self-explanatory in the case of the product. However, looking at the processes, we can elucidate 3 aspects we must consider and model for each of the level 1 processes. Time horizon refers to the length of time a pricing prediction for a tariff is made. This sets the limit for how further in the future the user can look for energy prices. Refresh rate refers to the frequency at which the tariff prices change, so the price might not be fixed, and change every day around midday. Finally, the time resolution refers to the smallest interval a prediction is made for, so if the price is defined in 15-minute intervals, 30 minutes, 1-hour, and so on.

5.2 Functional Architecture

This chapter describes the functional architecture of the LuSiTa table lamp, including the product's modes, components and interfaces, and how they operate and communicate. This section is described with more detail in LuSiTa Systems´s concept.

5.2.1 Modes of Operation

The LuSiTa table lamp has two modes of operation: manual and automatic. In manual mode, the user can control the lamp's colour and brightness settings manually, using the lamp's control panel. In automatic mode, the lamp adjusts its colour and brightness settings automatically based on real-time electricity prices, as well as ambient lighting conditions.

5.2.2 Components and Interfaces

The LuSiTa table lamp has several sub-components, each with its interface and functionality:

- Lamp Body: This is the main body of the lamp, which houses the LED lights and all the other components.
- Physical Interface: The display is located on the lamp body and allows the user to manually adjust the lamp's colour and brightness settings, while also displaying real-time electricity prices.
- Mobile Interface: The mobile interface for LuSiTa is designed to allow the user to control and monitor the lamp's behaviour from their smartphone.
- Processor[1][3]: The processor is the brain of the lamp, controlling the lamp's overall functionality and communication with other sub-components.
- LED interface: consists of the unit that contains the hardware responsible for the illumination.
- Database: stores information about electricity prices. This information is updated regularly to ensure the lamp displays the most up-to-date electricity prices and adjusts its behaviour accordingly.

5.2.3 Functional Architecture Diagram

The following diagrams show the functional architecture of the LuSiTa table lamp, including the sub-components and interfaces of the product and how they operate and communicate with each other:

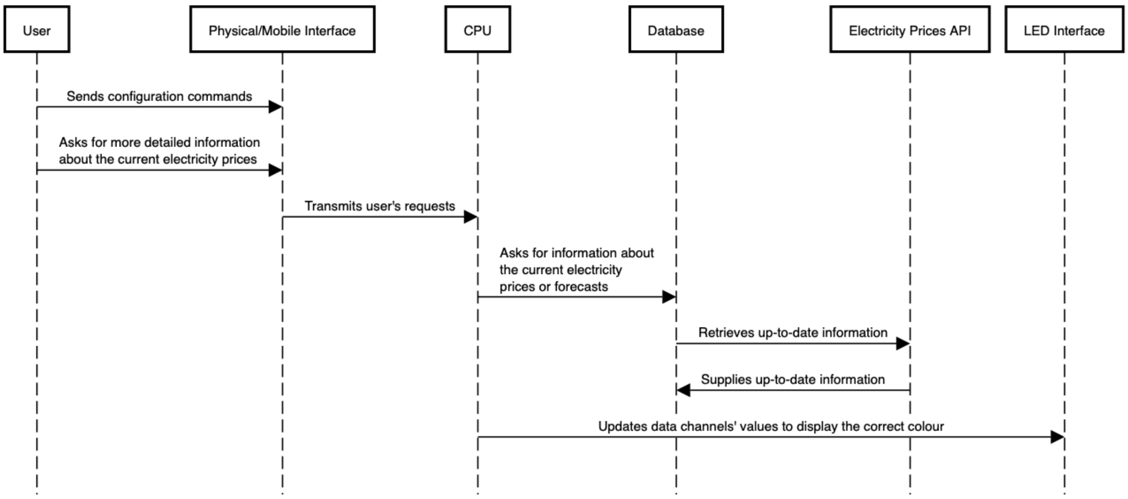


Figure 5.2: UML Sequence Diagram representing the functional architecture

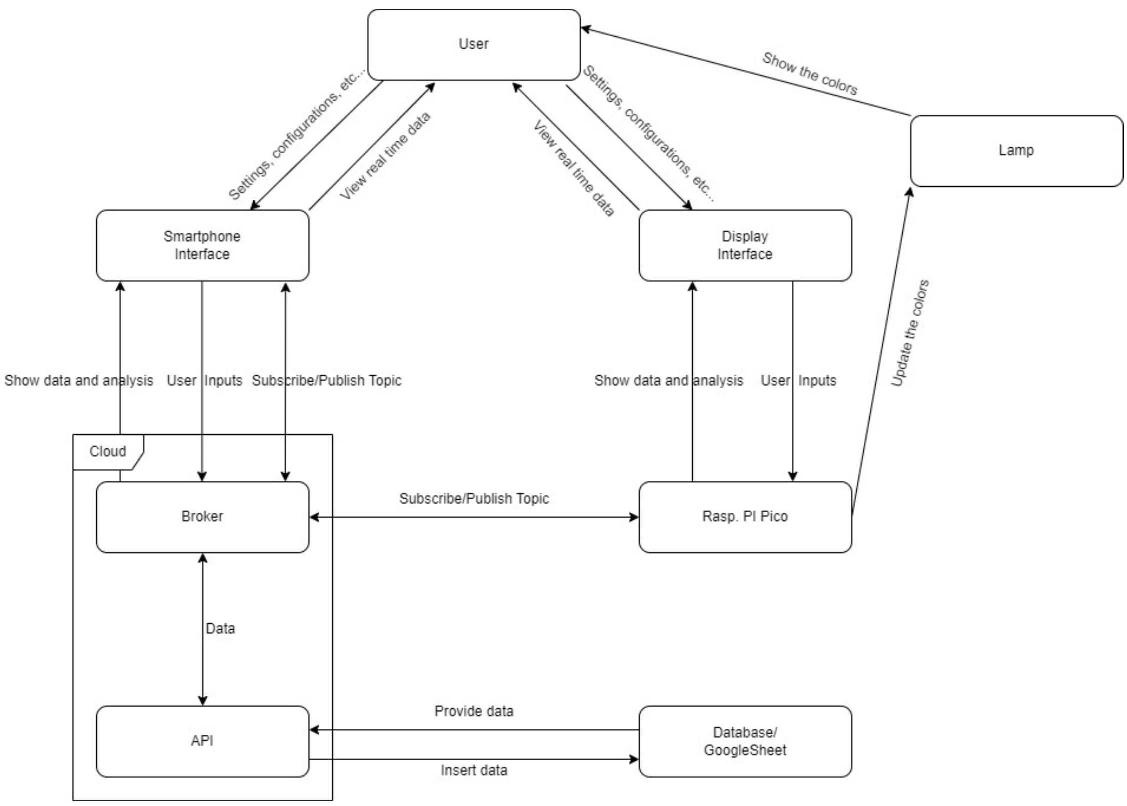


Figure 5.3: Functional architecture

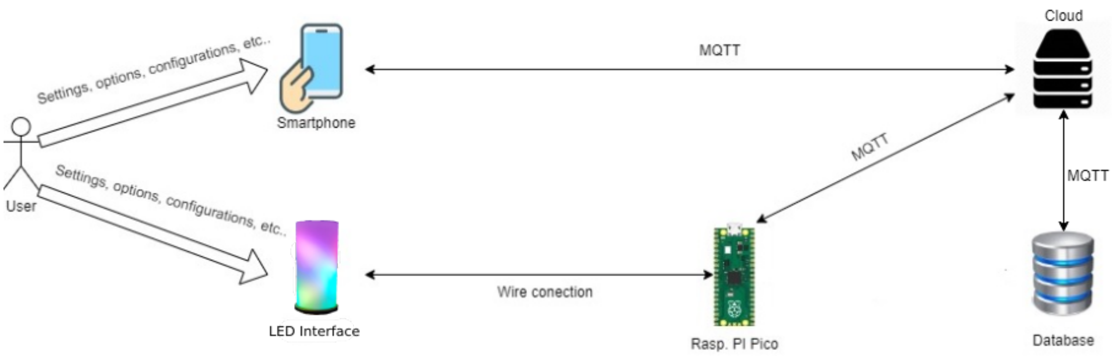


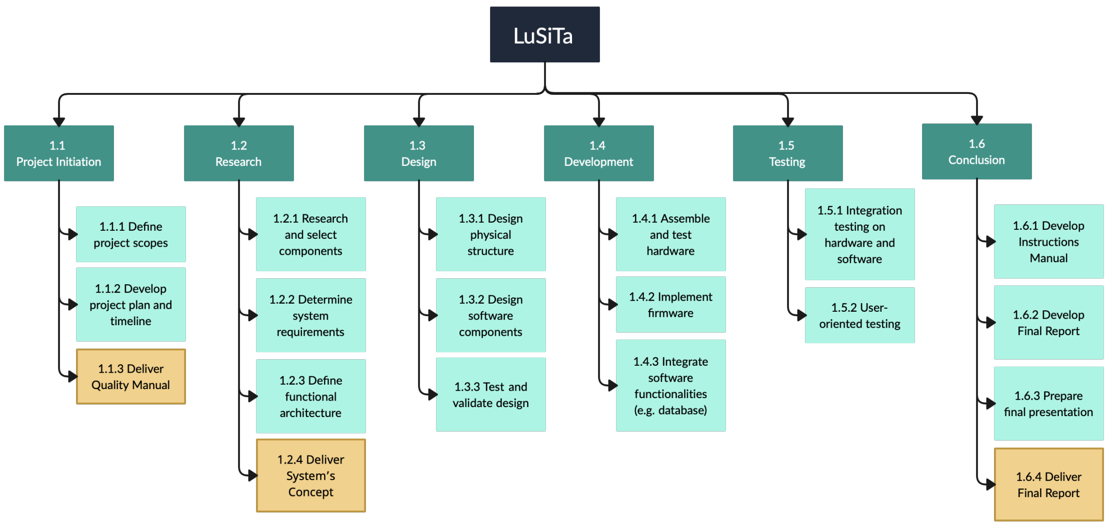
Figure 5.4: System communications

Chapter 6

Work breakdown structure

In order to effectively manage the LuSiTa project, a Work Breakdown Structure (WBS) has been developed to define the project deliverables and their associated activities. This approach helps to organize and prioritize project tasks, allocate resources and responsibilities, and track progress against the project plan. The WBS provides a visual representation of the project scope and is used as a tool to assist in project management and control.

The following diagram represents the Work Breakdown Structure for the LuSiTa project, which has been divided into several phases and sub-phases, with specific deliverables and activities associated with each. The WBS is presented in a hierarchical structure, where each level represents a more detailed breakdown of the previous level. The WBS provides a framework for project planning and tracking, allowing for easy identification of tasks, their relationships and dependencies, and the assignment of resources and timelines.

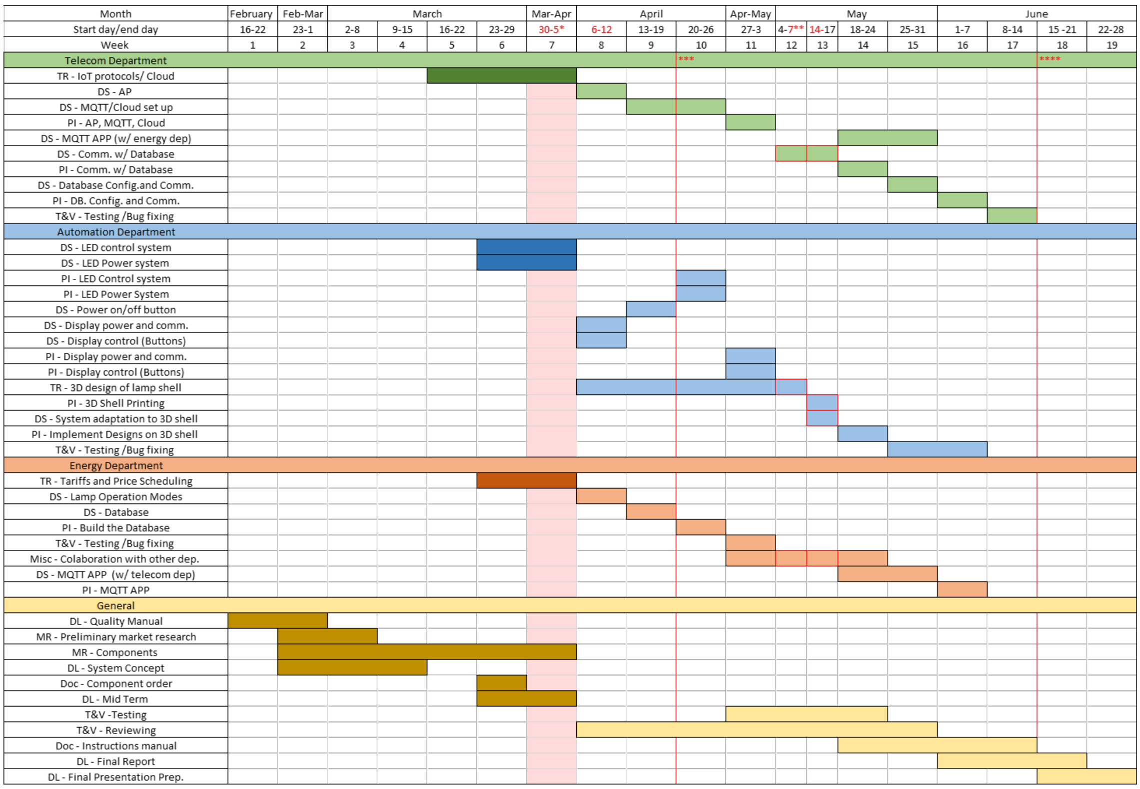


WBS diagram

6.1 Gantt chart for LuSiTa

The following chart lays out the work schedule for LuSiTa as designed by the project manager and agreed upon by the entire team.

The elaboration of the chart took into consideration aspects including the expected difficulty of the tasks, the time it will take to accomplish them, the available time for the team, possible unforeseen problems and other minor considerations. It was also taken into consideration the interruption of the semester for Easter and the academic week. In the first case, it was agreed that the work would still be carried out by the team, as the delegated tasks could be done independently. An important time stamp is the probable arrival of the purchased material. Furthermore, it was decided that all work should be finished by June 15, as to facilitate any corrections and the preparation of the final deliverable and presentation.



TR-	Technical research
DS-	Design stage
PI-	Product implementation
DL-	Deliverable
MR-	Market Research
Doc-	Other Documentation
T&V-	Testing and Validation

*-	Easter Interruption (03/04-10/04)
**-	Academic week (08/05-13/05)
***-	Expected Component Delivery
****-	Project Deadline

Figure 6.1: Gantt chart

Chapter 7

Developed work and preliminary results

Up to this moment, the developed work is centred around investigating the requirements of LuSita and applying them to the component research.

This General Ledger is a crucial step in the company's accounting process that will note relevant debit or credit amounts. Then, those debit and credit values will undergo further calculations, in order to achieve a final balance of expenses. This file will also explain the process used to decide which components will be used in this project.

7.1 LED's

The choice of LEDs is probably the most important one since it will affect the project structure and planning. The first decision taken was to use a LED Strip instead of individual LEDs because it outputs a higher power (light).

Then, it was decided that the LED strip doesn't need waterproof protection since it will already be protected by the shell of the lamp. Also, it was decided that it would be better if the LED strip had a higher number of LEDs per meter, rather than long spaces between them. With that in mind, a black LED Strip with two meters was chosen (which is more than what the product needs, so it can cover possible mistakes) with 120 LEDs and with a WS2812B chip that can be programmed with an Adafruit neopixel library.

Furthermore, the strip is very bendable, resistant to physical touch and can be cut into smaller strips that can be adapted to our project, which makes it easier to be handled and to be reused. Finally, these LEDs were the most quality/price worthy within the websites with a partnership with our supplier.

7.2 Microcontroller

The microcontroller is an essential part of the project, as it is responsible for commanding the LEDs according to the data received, switching the lamp's modes and presenting information on the display. Considering this, two options were found: a Raspberry Pi Pico W and an ESP32-C3-32S. However, after a long group deliberation, it was decided that the first one would be the best option.

This microcontroller board comes with built-in Wi-Fi connectivity(2.4GHz 802.11n wireless LAN), making it easier to connect to a wide range of wireless devices and networks. Like the standard Pico, power and basic connectivity go through a Micro-USB port, although you can also use the board pins to power the device, which has low power usage. Also, it has its own SDK that can be used to program in C/C++ and micropython.

Finally, most of the company's collaborators are familiar with this microcontroller, which can be useful when we get to programming the board. With that in mind, it was also decided that it would be ordered in the Portuguese platform "Mauser" since it's a reliable and fast distributor.

7.3 PCB

The PCB, even though it's not the most important component, it will give stability and protection to the Pico and all the wires welded to it. With that in mind, we opted to not order a specific PCB for the project, which would be a lot more expensive, and instead, order a generic perforated circuit board.

The board chosen is a board of 72x47mm which fits exactly with the Pico's measures, which are 21 x 51.3mm, that way it won't take up much space in the lamp. Finally, it was decided that the board would also be ordered from "Mauser" with the intent of ordering most of the components from the same platform together and paying fewer shipping taxes.

7.4 Display

The display must have the capacity of providing a visual interface with the information of actual date and time, which tariff mode is being applied at the moment, the battery percentage and the state of the Wi-Fi connection. So, the user can get all that information just by looking at the display. With that in mind, a simple but effective display would be the best option for this project.

With that in mind, it was decided that the Display our product would have would be the OLED of 0,91" also from the same platform, "Mauser". This display does not need a backlight, has a low energy consumption and fits exactly with the dimensions needed.

7.5 Power Supply

The power supply market survey was done with one major goal: to have the most long-lasting (but still affordable) battery that could maintain the lamp ON, while respecting the portable requisite.

Due to the input voltage of the microcontroller and the LEDs, it was agreed to use a 5V power supply. Another goal was to have the biggest current deposit in order to maintain the lamp working for the longest time. With that in mind, we chose a lithium polymer power bank with 10A of capacity and 2,1A of output current, also it outputs 5 Volts, which is exactly the required voltage.

7.6 Extra Components

7.6.1 GPIO pins

For this project, it was required 40 pins to weld the Raspberry Pi Pico W to the Perforated board, in that way, two bars of twenty pins would be needed. Thus, two bars of pins of 2.54mm compatible with The Pi Pico were chosen also from Mauser.

7.6.1.1 Buttons

In this project, the user needs to be able to interact with the system so, buttons would be required.

First, the system would need an On/Off to be able to turn the power On and cut it when it's not being used. The chosen button has a red LED inside, to indicate that the product is on and was the most quality/cost-worthy found.

Secondly, the system would need buttons to navigate through the different modes of our product. With that in mind, a simple and extremely affordable set of buttons were chosen.

7.6.1.2 PDS

The PDS is a power switch with digital logic activation which opens or closes the circuit according to the logic signal at the gate. This component will be useful to cut the LEDs power supply when the user wishes to turn it off, also it protects the LEDs from possible current leakage that would happen if it was connected directly to the power supply. Thinking of that, it was decided that there would be two choices for PDS. Both work at 5V with a maximum current of 2A and have a very simple design, only needing one output.

1. TPS2034P (TH)

   This PDS is easier to assemble in the Perforated Board since is big enough to be welded to it.

2. AP22818AKCWT-7(SMD)

   This PDS is much cheaper and brings a lot of protection to the circuit.

With that being said, both of them were ordered since it's still unclear which one we will be able to weld to the board.

7.7 Accounts Table

Table 7.1: GlowTech's Expenses - Option 1

	Name	Link	Order Date	Price (€)
LED	Addressable RGB LED Strip	https://tinyurl.com/3754m4xj	22-03-2023	13,95
Micro Controller	2xRaspberry Pi Pico W	https://tinyurl.com/scyusubf	22-03-202	2x7,49
PCB	2 x Perforated Circuit Board	https://tinyurl.com/vbe8xrzr	22-03-202	2x1,20
Display	OLED de 0,91"	https://tinyurl.com/2p8x4ymd	22-03-202	5,38
Battery	2 x Power Bank	https://tinyurl.com/2s43fmby	22-03-202	2x11,99
Extra Components				
	2 x GPIO Pins	https://tinyurl.com/ycy63rp7	22-03-202	2x1,40
	6x Tactile Buttons	https://tinyurl.com/ycxhx6ky	22-03-202	6x0,50
	1 On/Off Button	https://tinyurl.com/5n93nd9s	22-03-202	1,50
PDS	2x TPS2034P (TH)	https://tinyurl.com/4ux39va3	22-03-202	2x 2,67
PDS	2x AP22818AKCWT-7(SMD)	https://tinyurl.com/y24scr7n	22-03-202	2x 0,43
Total Spent				74,09
Total Per Product				42,005

7.8 Protocols

How the client communicates with LuSiTa is a crucial part of the project. The search for messaging protocols and how to implement them in LuSiTa's context was done taking into account the fact that, when first used, the lamp won't have a connection to wifi, so the client must be able to establish that connection effortlessly. When connected to wifi there is the need to assuring that the client can communicate even in an unreliable network and without having any privacy or security concerns. Besides that, it was taken into account the limited processing power and memory of the microprocessor chosen, the difficulty of the protocol implementation and the type of data that is expected to be sent between Lusita and the client. During the investigation, we came across several interesting possibilities such as zigBee light link, coAP, MQTT and HTTP[5]. These were filtered, according to the criteria already mentioned, and finally chosen two protocols, HTTP and MQTT. With these protocols in mind, the team thought of three implementation possibilities, one using only MQTT, another using only HTTP and another using the two in different phases.

7.8.1 MQTT Only implementation:

The implementation using only MQTT consisted of hosting an MQTT broker on the microprocessor and establishing the connection between the client, which uses the 3rd party app MQTT DASH, and the broker using an access point, hosted in the microprocessor. The team had some concerns with this possibility regarding the memory and possible hit that the processing power of the microprocessor could take and the fact that the IP of the broker when connected to the wifi will change, complicating the implementation and possibly making the product less user friendly, given that the user might have to update the IP on MQTT DASH. This possibility was not discarded, but instead turned into a plan B in case there is some problem in the implementation process.

7.8.2 HTTP only implementation:

The second implementation consisted of hosting an HTTP server of the microprocessor and similarly to the first possibility the client connects to it using a browser. This possibility was discarded, because of possible security and privacy problems that arise when LuSiTa is connected to wifi and some doubts facing the server implementation.

7.8.3 MQTT and HTTP implementation:

The chosen possibility consists of hosting an HTTP server on the microprocessor and using an access point to establish a connection between the server and the user, while LuSiTa is not connected to wifi. Then, when the user connects to LuSiTa's access point, he will be presented with a captive portal where he can input the wifi data. With this data, Lusita connects to wifi, deactivating the access point. When connected to the wifi, the microprocessor establishes a connection to a MQTT broker hosted in the cloud and the client, using the 3rd party app MQTT Dash, can connect to the same broker subscribing to the topic created by his LuSiTa Lamp.

7.8.4 Broker:

The choice of the cloud-hosted MQTT broker is fundamental, as it needs to be reliable and at the same time guarantee security and privacy measures. With that in mind, the chosen platform was the AWS IoT Core, which is a cloud platform provided by Amazon Web Services (AWS) that allows devices to connect securely to the cloud and interact with other devices and services. One of the services offered is the possibility of hosting an MQTT Broker that meets the used criteria.

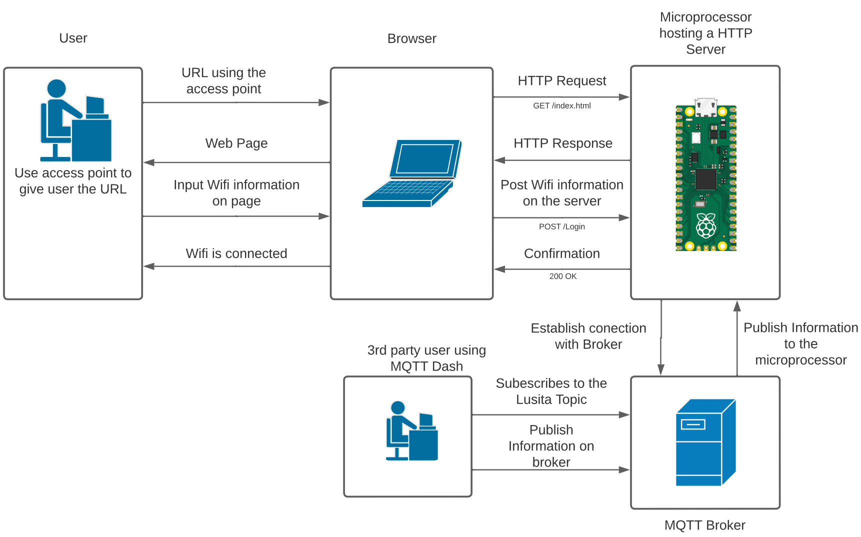


Figure 7.1: Protocol diagram

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