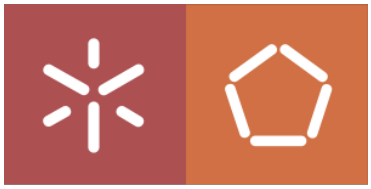

Universidade do Minho
Escola de Engenharia

Smart Street Lighting

Master in Industrial Eletronics and Computers Engeneering

Embedded Systems

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Acronyms

API Application Programming Interface

HPS High Pressure Sodium

IoT Internet of Things

LED Light-Emitting Diode

Chapter 1

Introduction

1.1 Problem Statement

Nowadays, the energy crisis is a constant theme because of the inflated energy prices [1]. Furthermore, huge energy consumption is a burden to the environment, as not all means of energy production are non-polluting. According to "Our World in Data"[2], in 2019, 63,3% of eletrical energy production comes from fossil fuels. It is known that, in cities, street lamps are continuously switched on at night, most of the time unnecessarily glowing with its full intensity in the absence of any activities in the street. This leads to a great waste of energy, also contributing to the increase in light pollution. As claimed by National Geographic [3], 83% of world population lives under light-polluted skies. This is a problem since it alters the biochemical rhythms that normally flow with natural light levels and also endangers ecosystems by harming animals whose life cycles depend on dark.

With that in mind, the main objective of this project is the creation of a monitoring device, capable of controlling an intelligent street lamps network. These are capable of turning on only when they detect movement in the surroundings, adjusting their luminosity according to the needs of the surrounding environment. The device to be developed must be able to connect to all the sensors of each street lamp, must have knowledge of each operating conditions and location, and also must be able to control the street lamps individually, if necessary.

1.2 Problem Statement Analysis

In order to have a better and deeper understanding of the problem, it's essential to identify the entities involved and their relationships. Using that analysis, a system diagram can be built, figure 1.1, relating the known entities and presenting some attributes.

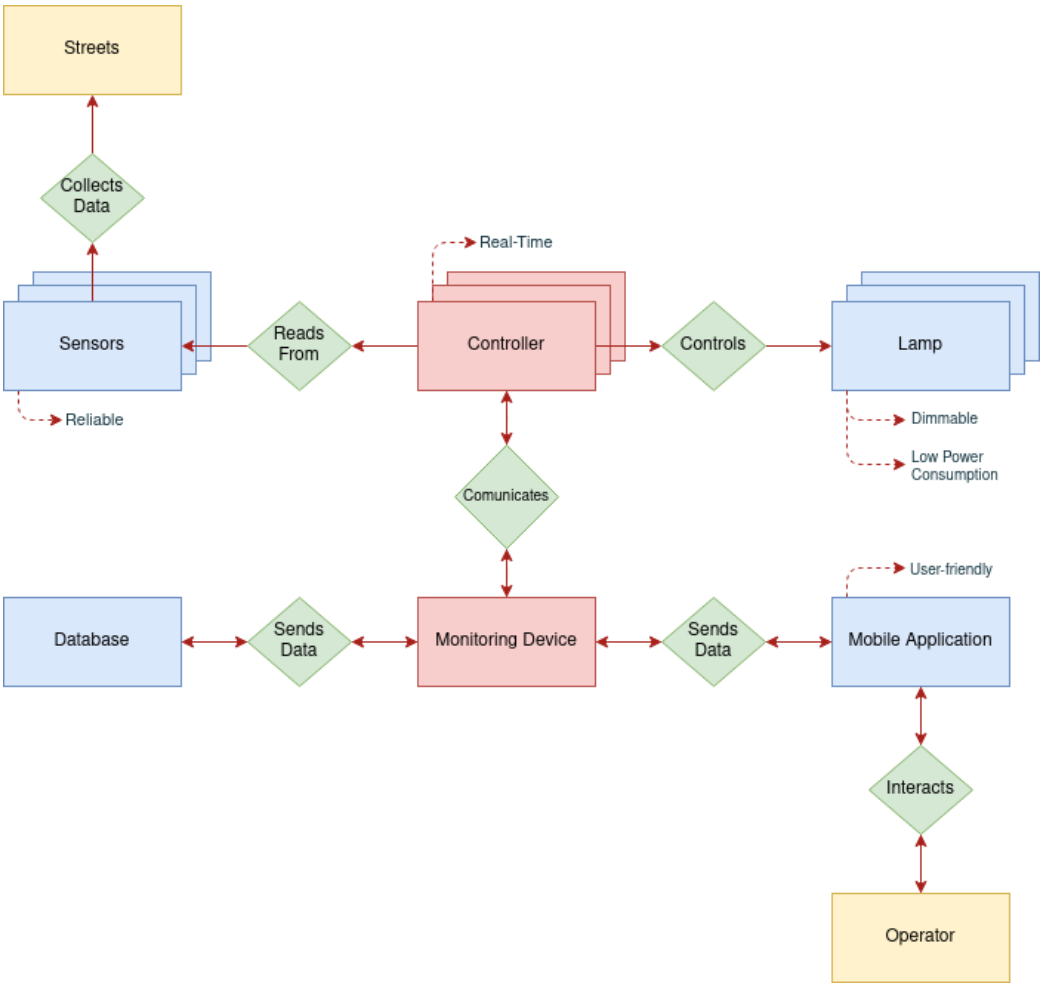

Figure 1.1: Problem Statement Analysis Diagram.

The main purpose of this system is to control a network of smart street lamps, that is, turning them on when movement in the surroundings is detected and also adjusting their brightness according to the ambient light

conditions. The system consists of a monitoring device, which communicates with various controllers. Each controller manages a single light pole, ensuring that its lamp lights up whenever motion is detected, through its sensors. The monitoring device receives and sends data to a database, which contains information about all lamp posts, and communicates with a mobile application. A responsible person for the lamp posts network, the operator, uses the application to obtain knowledge about this network. In addition, the monitoring device can also request each controller to turn on their lamp, regardless of whether or not there is movement in the vicinity of this pole.

Chapter 2

Analysis

2.1 Market Research

2.1.1 Market Definition

Public lighting is essential to the society quality of life, since it allows citizens to enjoy public spaces at night, providing greater security. "In 1417, the Mayor of London ordered all houses to hang lanterns outdoors after dark during the winter months. This marked the first organized public lighting." [4]. From oil lamps to Light-Emitting Diode (LED) lamps, public lighting has become a more efficient, cheaper and less polluting way of lighting the streets.

Currently, most of the lamps used in public lighting are High Pressure Sodium (HPS). This is a gas-discharge lamp that uses sodium to produce light, at a distinctively yellow-orange, monochromatic glow. These are more efficient than the older incandescent lights, have a cheaper price and have a higher lumen efficiency than older street light types. However, these have a higher maintenance cost and operation cost than the LED lamps. Also, HPS lamps doesn't have the advantage of being a directional light, like LED does, meaning that HPS light gets emitted in various directions, contributing to light pollution. [5]

The market is driven by several factors, among which are regulatory policies, Internet of Things (IoT) convergence, and LED price, in addition to the culture and morphology of each area. LED technology can generate savings of more than 60 percent of energy costs [3], allowing payback of the initial investment. But, on the other hand, it comes with hidden costs: people tend

to overuse it and over-illuminate areas, wasting energy unnecessarily by casting large amounts of light in all directions, emitting bluelight wavelengths that bounce around in the atmosphere, badly affecting animals, including humans.

2.1.2 Market Dimension and Growth

Cities are looking at smart infrastructure to reduce costs, improve sustainability, and provide better services to residents. Nowadays, Telensa is the market share leader in smart street lighting with more than ten years of experience. PLANet is an intelligent street lighting system, consisting of wireless nodes connecting individual lights, a dedicated network owned by the city and a central management application. This system reduces energy and maintenance costs associated with street lighting and also improves quality of maintenance through automatic fault reporting. Doncaster, the largest metropolitan borough in England, houses over 45,000 smart Telensa streetlights, covering 220 square miles, achieving energy savings of approximately 1,5 million euros annually, with potential to increase this in the future [6].

FLASHNET is a company focused on developing intelligent systems for smarter cities and better infrastructures and have created a solution that provides the right amount of light where and when needed to lighten the streets, the inteliLIGHT [7]. Using the existing infrastructure, this solution saves money and transforms the existing distribution level network into an intelligent infrastructure of the future. Furthermore, the system is integrated with major IoT platforms and provides Application Programming Interface (API) connectivity with City Management applications, ensuring compatibility with existing smart lighting and smart city initiatives.

Note that smart street light is an emerging technology that, despite being established in the market, is still relatively uncommon in cities due to the initial investment it entails. However, it is clear that in the long run it is compensatory and now, as the consequences of light pollution tiptoe from the shadows and into the spotlight, cities, regulatory agencies, and conservation groups are agitating for solutions.

2.2 System

2.2.1 System Overview

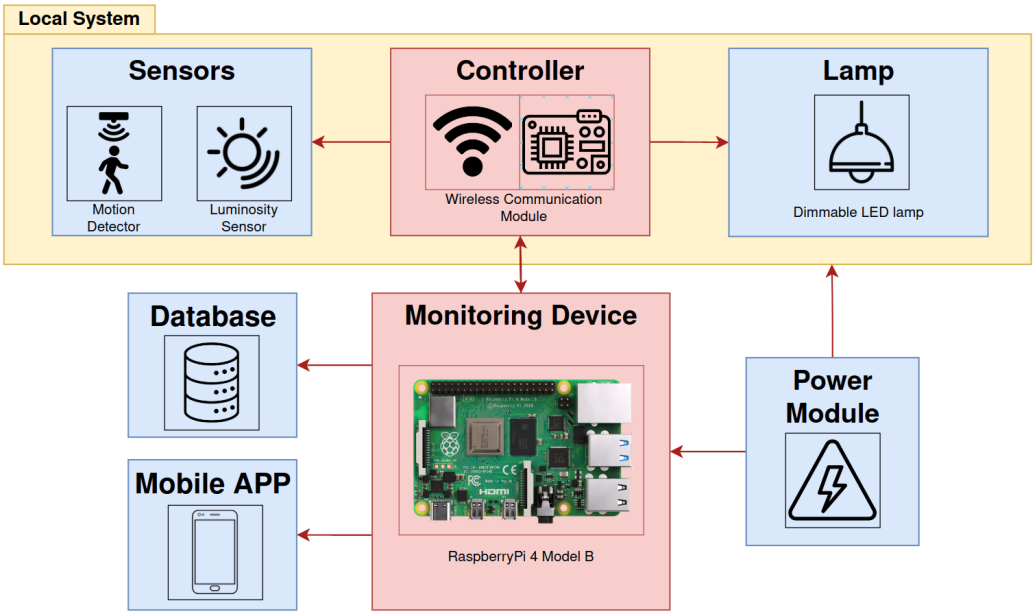

Figure 2.1: System Overview Diagram.

2.2.2 System Requirements and Constraints

2.3 Software Architecture

2.4 Hardware Architecture

2.5 Task Division and Gantt Chart

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