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LORAWAN-BASED DASHBOARD FOR EFFICIENT MONITORING AND CONTROL OF OUTDOOR LIGHTING SYSTEMS

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ABSTRACT

This article approaches the development of a dashboard that allows the control and monitoring of the luminaires at the TecNM-Instituto Tecnológico de Saltillo, for this purpose, devices with LoRaWAN technology were used with project-feasible characteristics, such as acquisition of electrical information and the consumption of the luminaires. These devices were registered on The Things Stack, a network server that manages LoRaWAN devices and gateways. In addition, it provides an MQTT server, a protocol used to send commands or downlinks to devices. Through these commands it was possible to control the operation of the luminaires, as well as requesting information about them. The Node-RED development tool was used, within which JavaScript was used, as well as the different nodes provided by this tool, for the development of the dashboard and its functionality. The InfluxDB database was used to store the information obtained from devices; this information was used in the Grafana software, where graphics were generated to allow the user, more visual, to interpret the data. These three pieces of software were placed on a local server using Docker containers.

KEYWORDS: LoRaWAN, luminaires, nodes, controller, devices, gateways, The Things Stack, Node-RED, InfluxDB, Grafana, MQTT.

1 INTRODUCTION

Over the past few years, IoT has become one of the most important technologies of the 21st century. Now that we can connect everyday objects like kitchen appliances, cars, thermostats, baby monitors, to the internet via embedded devices, seamless communication is possible between people, processes, and things.[1]

In an enterprise context, IoT devices are used to monitor a wide range of parameters such as temperature, humidity, air quality, energy consumption, and machine performance. This data can be analyzed in real time to identify patterns, trends, and anomalies that can help businesses optimize their operations and improve their bottom line.[2]

The LoRaWAN specification targets key Internet of Things (IoT) requirements such as bi-directional communication, end-to-end security, mobility, and localization services.[3] Unlike other wireless communication technologies, it enables the deployment of a large set of battery-powered devices over a wide area in a simple and economically viable manner.[4]

2 MATERIALS AND METHODS

2.1 MATERIALS

For the development of the luminaires control and monitoring dashboard, it was necessary to have the following materials: node for the control and monitoring of luminaires, 7-pin NEMA socket, and LoRaWAN Gateway.

2.1.1 LoRaWAN Gateway IP67 - MultiTech Conduit

MultiTech Conduit® IP67 Base Stations is a ruggedized IoT gateway solution for outdoor LoRa® public or private network deployments. The IP67 is a highly scalable and certified solution capable of resisting the harshest environmental factors. These factors include moisture, dust, wind, rain, snow, and extreme heat, supporting LoRaWAN® applications in any environment. The enhanced Conduit IP67 solution can support thousands of LoRaWAN certified end nodes.[5] The gateway used is shown in Figure 1.

Figure 1: LoRaWAN Gateway IP67 - MultiTech Conduit.

2.1.2 CTW501-FL Smart Street Light Controller CTW501-FL

LoRaWAN smart street light controller is compatible with NEMA C136.41 socket. Additionally, it integrates features such as metering chip, dimming, controlling, tilt sensor, light sensor, dimming scheduling, and GPS. It can be managed and controlled remotely in real-time on a CMS platform via OpenAPI MQTT internet from anywhere.[6] The controller node is shown in Figure 2.

Figure 2: CTW501-FL Smart Street Light Controller.

2.1.3 7-pin NEMA socket

NEMA sockets are often used in outdoor lighting, particularly in street lighting. In 1979, the ANSI C136.10 standard was first proposed. This standard specifies a three-pin physical interface for twist-lock control of lighting installations. In 2013, NEMA added a new standard, ANSI C136.41, whose physical interface includes four new (low voltage) pins for dimming control and future service.[7] This NEMA socket is shown in Figure 3.

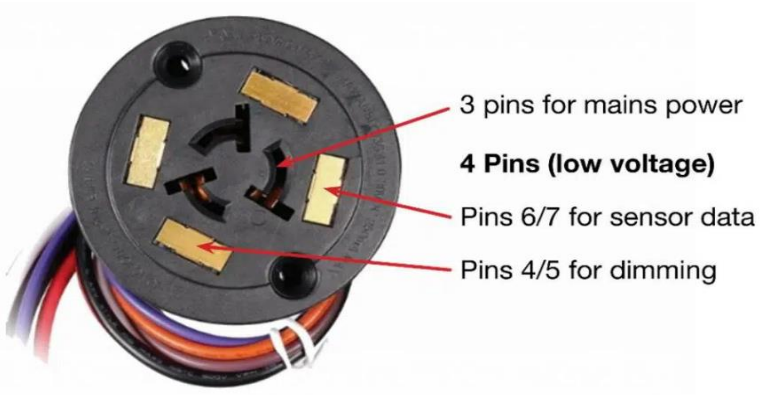

Figure 3: NEMA ANSI C136.41.

2.2 METHODS

Figure 4 shows a system network with various components that are interconnected. The system architecture consists of the following components.

- **CTW501-FL Smart Street Light Controller**: Receives the commands to turn on and off or activate and deactivate the photocell mode from the Gateway. In addition, it sends information about the consumption of luminaires to Gateway using the 915MHz frequency.
- **Gateway IP67 MultiTech Conduit**: Bridge between our controller devices and the network server that receives messages from the controller and forwards them to the network server and vice versa.
- **The Things Stack Cloud**: Network server that receives the commands and information obtained by the controller gateway and that, through the integration of the **MQTT** protocol, will send this data to the application server.
- **Node-RED**: Subscriber of the MQTT topic to receive and display the data obtained by the network server in a graphical user interface. As well as publishing messages with the commands in the topics. It also stores the data it receives in a time series database.
- **InfluxDB**: Database where the data of interest (consumption and power) of the luminaires will be stored.
- **Grafana**: Retrieves the stored data from the database to create visualizations that are easy to understand for the user.
- **Docker-Compose:** Contains the applications or services of the application server in containers.

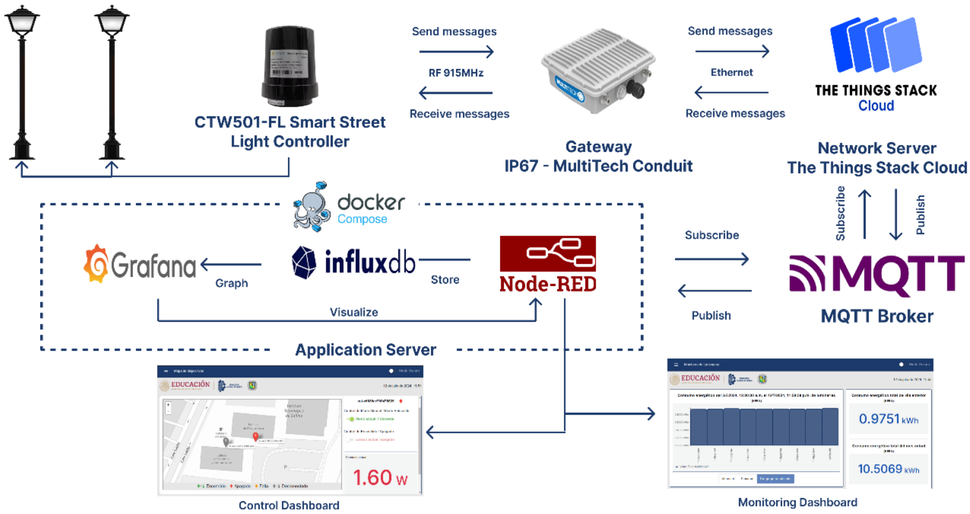

Figure 4: System architecture.

3 RESULTS AND DISCUSSION

3.1 RESULTS

On Figure 5 is shown the main page of the developed dashboard. It contains a map with the locations of the devices marked into it, once one of these marks is clicked on, a sidebar opens at the right side of the screen displaying the controls and information for that specific device. All devices show their own switches to control the working mode or to manually turn off/on the lights. When a device is set to photocell mode, which turns off or on the lights based on the ambient light detected, the switch used to turn off or on is disabled.

Below those controls, three graphs are shown to the user which contain useful information about the power consumption of the luminaire, such as the current power, the lower power registered and the highest.

Figure 5: Device map.

On Figure 6 is shown another tab called "Luminaire monitoring". This tab contains multiple graphs related to the luminaire's consumption in kilowatts per hour, and the conversion of this consumption to Mexican Pesos.

On the left is an historical graph of the consumption, each graph has three buttons used to change the time frame of the graph, the options are monthly, weekly or custom.

On the right side there are two graphs for each measurement. These graphs show the total of the last day and the total of the current month.

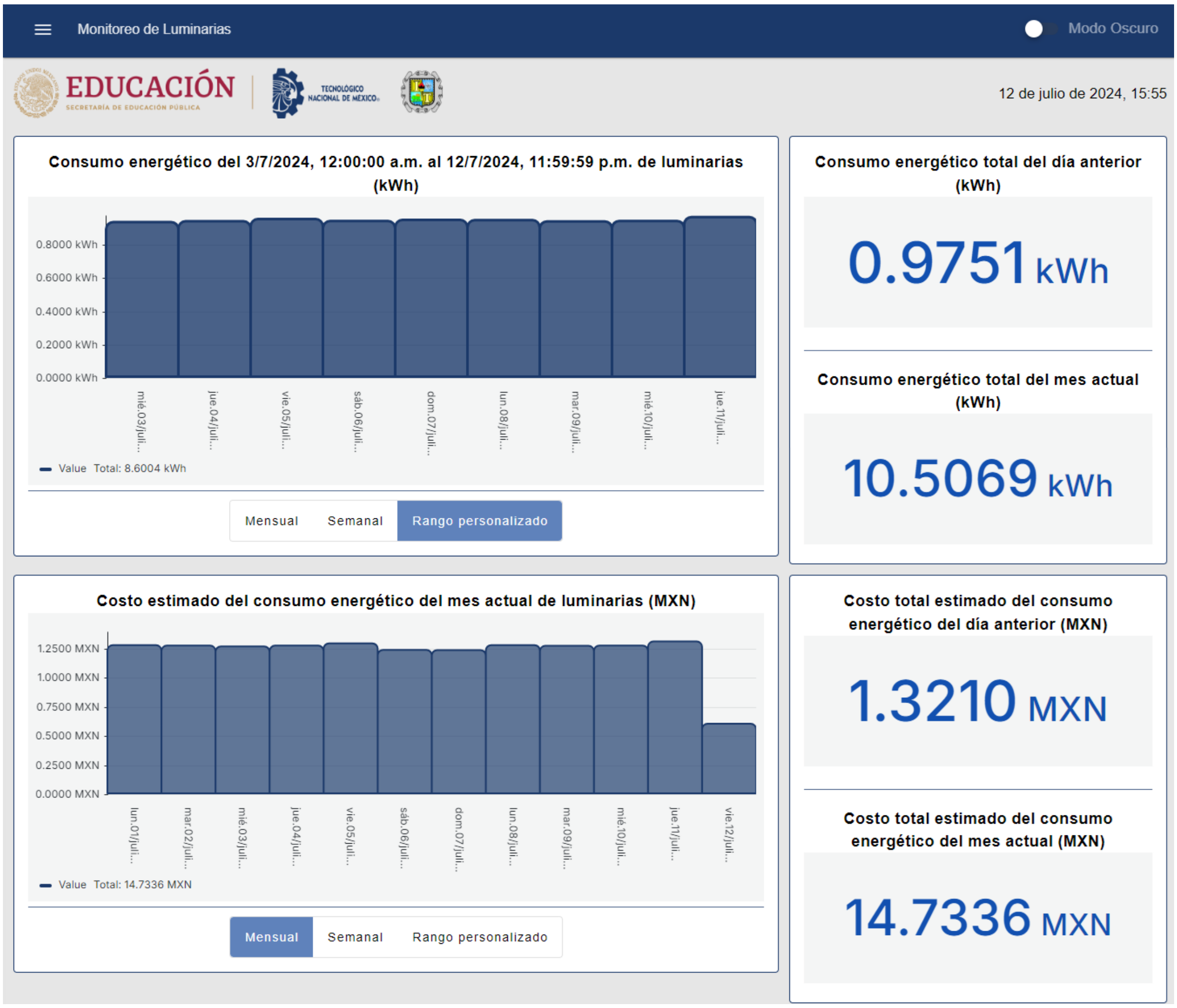

Figure 6. Luminaire Monitoring.

Figure 7 shows the tab "Devices". This tab contains some information about the status of the devices registered in the LoRaWAN server. On the top left side, the user can see the total number of devices registered, the number of devices connected and the number of disconnected. To the right, the user can filter the devices shown by their type. Below this, each device is displayed with its identifier, the type of device, and its status.

The devices of type luminaire have a button to show or hide the faults registered by the device.

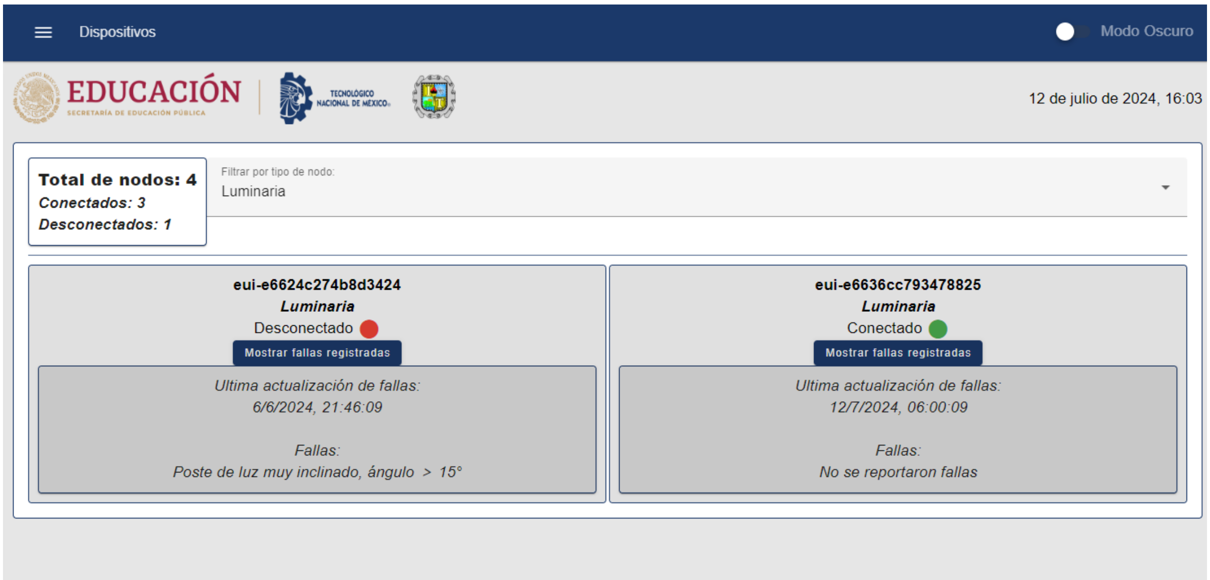

Figure 7: Devices.

CONCLUSIONS

A dashboard was successfully implemented on a local server at the institute, providing control over the luminaires of the campus. The information collected from the installed devices, mainly power consumption, is saved in a database on the server, which can be moved if needed to another server either locally or on the cloud.

The system manages to speed up the fault detection process in different ways.

- The devices report different types of failures to the user, which can be consulted in the devices tab.
- The power of the luminaires is constantly collected, allowing the user to identify the status of the luminaire's bulb.
- A map is provided with the location of each of the luminaires, allowing the user to know exactly where the faulty luminaire is located.

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