

## Smartlighting: System for management and monitoring street lights

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**Abstract.** City lighting represents an important part of the maintenance and energy budget for many towns. For these reasons, it is important to monitor and manage the energy consumption in order to reduce the consumption with a low impact to the users. The proposed system allows monitoring and managing the lighting to reduce consumption and the cost of the maintenance and management. The system was tested in a real environment and incorporates the software and hardware to carry out the needed functionality.

### 1 Introduction

The concept of smart cities 1 refers to the use of technologies in different aspects of urban life with the aim of improving increasing sustainability and bettering the quality of life for the inhabitants. The creation of smart cities facilitates the economic growth, sustainability and increase in the quality of life of all residents 1. As demands increase and budgets are reduced, new intelligent solutions are needed to manage the cities as a whole. According to the technologic map defined by the European Union, 50% of public building have to be intelligent by the year 2020 and must comply with various requirements for energy efficiency and sustainability defined by Europe 2.

In smart cities it is very important to optimize the use of public resources, such as street lights, and obtain the best possible performance. To reach this objective, it is necessary to develop an intelligent and efficient model of street lights that saves energy, facilitates maintenance, detects fails, and may be applied to other services such as: the deployment of WiFi networks based on the location of the city's lampposts, the intelligent management of traffic through the use of presence sensors, intelligent parking etc. To apply these technical advances to maintenance tasks, it is necessary to have a platform that can (i) manage the information gathered from all public roads and lighting devices, (ii) allow for both automatic and manual remote control and (iii) provide information to the maintenance staff and the intelligent system that analyzes the information.

SmartLighting 4 proposes a novel city street light management system that facilitates the maintenance tasks and reduces energy consumption. The main objective of the work is to reduce energy consumption without decreasing the services provided to the population. This aspect is important from an economic and sustainable development perspective. The system includes the hardware and software to remotely monitor and update the lighting parameters [5, 6, 7, 8]. Moreover, the system includes abstract layers to incorporate hardware from different manufacturers in a transparent way. A system with these characteristics can more efficiently manage the lighting, and will facilitate the development of personalized services with high capacity for the automatic adaptation to the context. Another important issue is maintenance. Basic maintenance tasks consist of replacing defective street lights or timers, repairing wiring in the streets etc. These problems can be automatically detected in real time by a system having these characteristics, thus facilitating and reducing maintenance costs by eliminating the need to manually review each lamp every 6 months.

The paper is organized as follows: section 2 includes a revision of related work, Section 3 describes our proposal, and finally sections 4 and 5 provide the preliminary results and conclusions obtained after testing the proposed approach.

## 2 Proposed system

The SmartLighting allows for the intelligent management of street lights, thus simplifying daily tasks as the supervision and maintenance of installations. The monitoring data will be accessible from several devices. The deployment includes the communications systems to transmit the information according to the state of the environment. In the case study, the data are transmitted through WiFi.

Figure 1 shows the distribution of the elements in the system. On the left side of the image, we can see the street lights on a public road which gather and send information to the server. The user can use a mobile, tablet or PC to connect to the central server and monitor or take necessary action with the street lights through the server. The server will manage the information automatically and will send orders to the street lights according to different schedules.



**Fig. 1.** System Structure

## 2.1 Lighting hardware

The lighting facilities have more or less the same structure: a set of Street lights with one or more bulbs, which are connected to the control panel. The power flows through the control panel and reaches the lamps, allowing the control panel to control and cut off electricity when necessary.

The control panel contains all the elements that govern the system. According to the level of automation and control granularity of the facilities, some of the elements may include:

- **Circuit breakers and low-leakage switches.**
- **Timer.**
- **Control node or controller.**
- **Counter.**
- **Network analyzer.**

The lamppost may contain:

- **One or more bulbs**
- Depending on the type of bulb (LED, mercury vapor, sodium vapor ...) it may include different ballasts or power supplies. The type of bulb and ballast sophistication may allow:
  - o On and off
  - o Dimming or control of light intensity across different protocols.
- In most modern lamps, we usually find luminaire controllers that communicate with the control node of the control panel and allow monitoring and controlling the lamp from the dashboard.

Figure 2 shows the architecture of the platform. Several hardware and software components that integrate SmartLighting are represented in the image. The proposed platform includes several hardware components deployed in electrical installations. For a light that must be controlled independently, it is necessary to incorporate a ballast and a control node to act on the ballast. It will also be necessary to incorporate the PLCs needed to transmit information to each luminary. Another component on which action is required is the control panel, which will include a Smart Server and connectivity to send information to the remote server. In addition to hardware management luminaries, the proposed platform includes light sensors, motion sensors and microphones to detect patterns of behavior among the residents and use them to create lighting models.

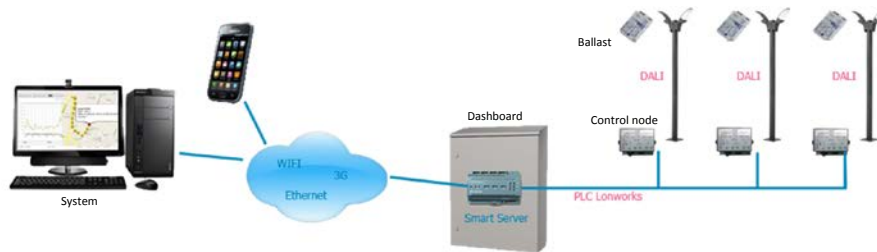


Fig. 2. Description of the system

## 2.2 Remote controller software

Figure 2 show the different elements that can be grouped as follows:

- The Graphical user interface to interact with the system, which is divided into two subsystems: the first is the visualization model to monitor the state of the lighting systems, and also includes the management system; the second is the display model associated with intelligent management that allows for automatic system control.
- Daemon: they are the processes responsible for implementing new algorithms for intelligent system behavior. These daemons receive instructions from the intelligent control and monitor the environment to act intelligently. These processes use the web services layer to obtain the missing information from the upper layers.
- Web services: The Web services layer includes a security module that is responsible for filtering information to prevent attacks that attempt to access information. Services will use the hardware layer interface to access the data from the devices. The hardware abstraction layer will define the access interface for each device.
- Data source: the software component will implement the mechanisms to access the information defined by the hardware abstraction layer. Each data source can be from a different manufacturer on the condition that the hardware abstraction layer and interfaces remain constant.

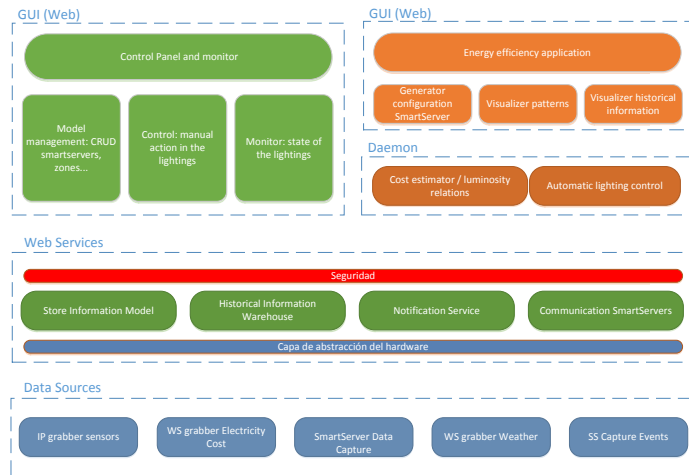


Fig. 3. Software architecture of the system

### 3 Results and conclusions

This work has presented the development of a web application to monitor and manage the lighting of different facilities in a smart city environment. The system was deployed in a village of Salamanca. All of the hardware required for management and control is incorporated in the control cabinet and the lights. Figure 4 shows the street and the hardware in the control cabinet. The hardware deployed is: the Echelon SmartServer 2.0 device, which allows the control and coordinating of other devices; the Circutor CVM-MINI network analyzer, which measures the overall system power consumption and a large number of parameters related to the energy consumed; the ISDE ASL-510-TCH controller, which regulates the luminosity according to the order received from the control node; the OSRAM OPTOTRONIC OPt DALI power supply ballast, which transforms the input energy into the correct signal for the LED lamps.



Fig. 4. a) Street with lamps b) Control cabinet

Management and monitoring is done through a web page that enables the monitoring and management tasks. The form allows data to be entered from the Smart Server, lighting, light or movement sensors, and other parameters such as location. This information is used to display the facilities. The system uses the presence and movement sensors to detect pedestrians and the flow of movement, and then uses the information to create calendars. To do so, the system incorporates ANOVA based clustering to detect similar days and EM to create lighting groups within each day. The lighting is distributed according to time segments to provide better services to the users and maintain costs.

The system makes it possible to manage the distribution of brightness according to various sensors, such as presence sensors, allowing the system to automatically adjust the illumination according to use, thus distinguishing between leisure, residential or business zones. In addition, the system can monitor and manage street lighting remotely thereby facilitating maintenance.

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