Science & Technology Development Journal – Engineering and Technology, 2(3):193-206

Open Access Full Text Article

Research Article

Development and performance analysis of intelligent street lighting for smart cities using LoRa Wan

Ngo Thanh Tung[1], Nguyen Hoai Phong[2], Ta Le Dinh Huy[3], Nguyen Minh Huy[3], Nguyen Dinh Tuyen[3], Le Minh Phuong[3,*]

ABSTRACT

Development and performance analysis of smart street lighting control system based using Led lamp and Lora Wireless communication is presented in this paper. Smart street lamps have been developed for over several years. These technologies have played an important role in urban safety, energy conservation. Currently, traditional street lights are automatically turned on or off based on timer or day/night sensor. LEDs are now the standard replacement for legacy lighting in most cities around the world. At the same time, smart controls are becoming more mainstream and are increasingly installed alongside LED deployments. Recently, the conventional light sources are replaced by Led, which have so many advantages such as: energy savings, long lifetime, high reliability, pure light color, fast response, and friendliness to the environment. Furthermore, the intensity of the LED can be controlled easily. In this paper, the smart lighting system is designed to control and monitor devices via wireless transmission frequencies below 1 GHz based on LoRa Network. The system will include many types of devices connected to each other by a gateway. The transmit distance is about 2km in the urban area and up to 5km in rural area. The proposed smart street public lighting provides three modes: Automatic mode, Remote control mode, Connection disconnection mode, Manual direct operation mode. The smart lighting system has been built at Ho Chi Minh City University of Technology to meet the standards for data transmission. Some experimental results are provided to validate the effectiveness of the proposed system.

Key words: Led Lighting, Smart lighting, Smart City, LoRaWan

[1]*Telecommunications University, Vietnam*

[2]*Industrial University of Ho Chi Minh City, Vietnam*

[3]*Ho Chi Minh City University of Technology, VNUHCM, Vietnam*

Correspondence

Le Minh Phuong, Ho Chi Minh City University of Technology, VNUHCM, Vietnam

Email: lmphuong@hcmut.edu.vn

History

- Received: 28-8-2019
- Accepted: 21/9/2019
- Published: 30/9/2019

DOI : 10.32508/stdjet.v2i3.570

INTRODUCTION

Recently, the intelligent street lighting system integrates smart technology and control capabilities is used wide to move to smart city. The smart street lighting provides remote lighting control that can better adjust the amount of time the lamp is turned on to minimize energy costs without reducing safety levels. This system has played an important role in urban safety, energy saving - efficient operation and maintenance. Smart lighting can also significantly reduce maintenance costs and simplify asset management. Smart street lighting system is capable of combining with electrical system and other applications in smart city [1–5]. Installing smart street lighting system for the following basic benefits: reduce energy costs due to better control of light usage, contextual lighting to enhance public safety at major events or in important areas, data from street light sensors can reduce maintenance and asset management costs, create a foundation for other smart city applications, providing communication networks and power grid [6,7].

Vietnam's cities and provinces are pushing for smart city program and combining technology with internet-connected devices to enhance municipal management and boost the economy. In order to create a smart city, the connection of smart lighting as the first step. These smart streetlights sense things like pollution, temperature, humidity and traffic congestion, all in an effort to help planners and commuters make better decisions.

In Vietnam, the lighting systems have not been completely using LED technology, only a few projects have been implementing the public lighting system using LED such as Hanoi, Da Nang and Ho Chi Minh City. Moreover, studies are limited in terms of monitoring and control technology due to the point-to-point deployment models, and only focus on saving power by replacing HPS lamps by LED lights. When the technology connected the lighting, system has not been paid attention. Some studies such as PowerEco of Global Electrical Technology Joint Stock Company offer solutions to control HPS/LED lighting systems through GPRS connections in point-to-point form. Other integrated solutions such as Rang Dong's intelligent control lighting system use PLC technology for buildings. Vlight company has built a centralized

Cite this article : Tung N T, Phong N H, Huy T L D, Huy N M, Tuyen N D, Phuong L M. **Development and performance analysis of intelligent street lighting for smart cities using LoRa Wan**. *Sci. Tech. Dev. J. – Engineering and Technology;* 2(3):193-206.

control system for the public lighting system in which the central control software can control the cabinets with GPRS wireless protocol. At each lamp, there is an IDIM set used to control the lights, IDIM sets are connected to radio control cabinets. Unconnected devices like these have not yet made use of the same features as systems that use multi-hop communication technology. Built-in central control software helps display data on a GIS map base to manage and control objects visually[8].

In this paper, the smart street lighting system using LoRaWAN data transmission technology is introduced. Its outstanding features: low power, long range, anti-interference capability and spread spectrum are easily achieved by interoperability and design of security features. It provides seamless interoperability between smart devices without complicated installation and provides the convenience for users, developers and businesses, enabling the deployment of Internet of Things[9,10]. The proposed smart street public lighting operates in four modes such as:

- Automatic mode, when connected to the center is maintained: Control the light according to the predetermined scenario specified by the control center or time control and the sensor appears;
- Remote control mode: lighting control according to the operator. In this mode, the manual operator activates the necessary change, and establishes the job. For example, in an emergency or during repair/maintenance work.
- Connection disconnection mode: Control light according to time and sensor appears; When a problem occurs, the device connecting the lights will control itself according to the program and script set up in the control unit.
- Manual direct operation mode: Light control at the installation cabinet. Employees who switch light by means of switches are installed in carrying out necessary verification during repair and maintenance of the facility.

In this paper, the possibilities of using LoRa technology for smart street lighting. The contributions of this paper are:

- Research, design and build a standard model Intelligent public lighting system using LED in accordance with the conditions of HCMC trend of modern lighting development.
- Design and build data transmission control system and application monitoring in public lighting systems using LED lights
- Design and build a software system to manage and control public lighting systems using LED lights

This paper is organized as following: the overview of the smart street lighting system is presented in section **Introduce to smart street lighting system.** The implementation of the smart lighting is described in section **Proposed smart street lighting control system and the implementation method**. In order to verify the system, the field test results and some discussions are provided in section **The experimental results and discussion**. Lasted, some conclusions are presented in last section.

INTRODUCE TO SMART STREET LIGHTING SYSTEM

Smart street lighting system

The overall smart lighting system is shown in **Figure 1.** On the left side of this figure, we can see the street lights collect all information via sensor and send it to the server by using wire/wireless network. The user can use the smart devices or PC to connect to the sever by using management system. The smart street lighting system uses modern data transfer technologies that allow connectivity, real-time analysis, reporting and other functions such as geolocation. As mentioned before, as shown in **Figure 1** shows the basic component of a smart lighting system, there are seven parts:

- Sensors are integrated in each street light to provide light control.
- Terminals transmit data from sensors connecting street lights to Gateways.
- Gateways collect data from all nearby street Led light.
- Sensors for smart city applications can connect to the same port.
- Gateways will send information to Cloud where the data is analyzed by a Server.
- Server: to controls light
- The server sends maintenance alerts for the lights and other issues.

Smart public lighting system has been developed for more than seven years. Most smart public lighting systems use technologies (PLC), ZigBee, SigFox and LoRa and NB-IoT. PLC, ZigBee, SigFox and LoRa technologies all require network construction and maintenance on the client side, especially NB-IoT technology uses the existing network in the network

Figure 1: **Smart lighting system.**

of general network operators when deploying 5G network and NB-IoT.

The development of communication technologies LPWAN has great success. From the point of view of licensing the frequency spectrum, the technology of the Internet of things can be divided into such components: working in the allowed and unresolved spectrum. The first category is represented by Lora, Sigfox, etc. Most of them are non-standard. The second is already known to all cellular communication technologies 2G/3G (such as GSM, CDMA, WCDMA and others), LTE technology that supports different types of terminals. The standards for these communication technologies working in the permitted spectrum are developed by international standards organizations. For example, 3GPP (GSM, WCDMA, LTE and others), as well as 3GPP2 (CDMA, etc).

There are some commercial solutions for street smart lighting such as: the CityTouch software of Philips, Owlet IoT City Management System of Schréder or Street Light Control (SLC) of Osram [11–13]. These solutions have some advantages such as:

CityTouch software [11]

- Support decision making by being able to manage luminaires, measure power consumption, monitor system status, ...
- Future capabilities: This is an open system that can support future sensors, cameras, or other IoT smart devices.
- Easy upgrade and expansion: can be applied to existing and newly invested lighting systems.
- Save energy and reduce operating costs: It is possible to reduce light on areas, roads or even individual luminaires leading to energy efficiency.

Owlet IoT City Management System [12]

- Strengthening security and order: the system is reliable and highly customizable; under all conditions always ensure enough light.
- Increased flexibility of lighting: allows users to control and monitor each luminaire or group of luminaires depending on the actual situation.
- Deploy quickly and easily: Owlet IoT lamp controller has Plug and Play function, so it only needs to plug and play.

Street Light Control[13]

- Intelligent hybrid architecture: there is a combination of taking advantage of both forms: control from Owlet virtual server and control from actual field sensors.
- Compatible with a variety of sensors.
- Locate luminaire coordinates quickly: due to the built-in GPS module in the Owlet IoT lamp controller, luminaire coordinates are automatically determined quickly, accurately, saving costs, effort in drawing map.

However, these companies' sale the smart lamps which are compatible with the software. Furthermore, the price of these solutions is very high and it is difficult to apply in Ho Chi Minh city due to security reason.

Introduction to LORA WAN

The LoRa (Long Range) spread spectrum is a patented modulation developed by Semtech based on the chirp spread spectrum (CSS) modulation. LoRa provides long range and low-power consumption, a low data rate, and secure data transmission. LoRa can be used with public, private, or hybrid networks to achieve a greater range than cellular networks. LoRa technology can easily integrate with existing networks and enables low-cost, battery-operated Internet of Things (IoT) applications. LoRa uses license-free sub-gigahertz radio frequency bands like 169 MHz, 433 MHz, 868 MHz (Europe) and 915 MHz (North America). LoRa enables long-range transmissions (more than 10 km in rural areas) with low power consumption. The technology is presented in two parts: LoRa, the physical layer and LoRaWAN (Long Range Wide Area Network), the upper layers. The advantages of LoRa WAN include:

- Low supported sensors and wide coverage are measured in kilometers.
- Operating on free frequencies (without licenses), there are no prepaid licensing costs to use the technology.
- Low power means long battery life for devices. Sensor batteries can last for 2–5 years (Type A and Type B)
- LoRa Single Gate Device is designed to handle thousands of devices or end buttons.
- It is very easy to deploy due to its simple architecture
- It is widely used for M2M / IoT applications.
- Better payload size (100 bytes), compared to SigFox is 12 bytes
- Open: an open alliance and an open standard. Open technology compared to competitors SigFox.
- Do not limit the maximum number of messages daily (compared to SigFox limit 140 / day)
- LoRaWAN has the benefit of being an alliance with an open approach instead of an exclusive method (SigFox).
- Long range allows solutions like smart city application.
- Low bandwidth makes it ideal for real IoT deployment with less data and / or with intermittent data transfer.
- Low connection cost (er).
- Wireless deployment, easy to install and fast.
- Security: a security layer for the network and a layer for applications with AES encryption.
- Full bi-directional communication.
- Supported by CISCO, IBM and other 500 member companies of the LoRa Alliance.

Operation principle of LoRa Wan

The system includes a central server, Lora technology gateways (ports or hubs) and terminals (points or nodes). Packets come from endpoints to ports, then to the next chain link, central server, then they reach the application server and then point to the user. The sensors are located remotely, automatically and operate on batteries (wireless temperature sensors, ambient light sensors, monitoring of electrical network parameters, security and other types). The application server can remotely control the end device and receive necessary information from them.

LoRaWAN has a two-star (star of stars) link structure. Each endpoint cannot be attached to a specific station. Data is received by several centers at the same time, each center will be sent to the central server by traditional technologies (mobile/satellite, Ethernet, Wi-Fi) via TCP/IP. The central server processes data, adjusts its speed, performs security checks and schedules confirmation of receipt via the optimal port. An important feature of Lora's Gateway technologies is the ability to simultaneously receive data at different speeds on the same channel. If the sensor is placed near the gate, there is no need to reduce the transmission rate, otherwise it will lose the channel longer than usual. Speeding helps reduce broadcast time and allows other nodes to transmit information, so this adaptive change in speed allows you to optimize the battery life of the last button.

Hubs can be installed inside buildings, on rooftops or towers. The protocol provides for bidirectional transmission, but mostly it is done from sensors to ports. The device is based on asynchronous transmission: the end devices are turned on only when they have something to play, the rest of them are in sleep mode.

PROPOSED SMART STREET LIGHTING CONTROL SYSTEM AND THE IMPLEMENTATION METHOD

The smart street lighting system using LoRaWAN data transmission technology - is a low-power radio frequency wireless transmission technology, bringing the concept of Internet of Things closer to large scale in terms of possibilities technical and cost-effective. Its outstanding features: low power, long range, anti-interference capability and spread spectrum are easily achieved by interoperability and design of security features. It provides seamless interoperability between smart devices without complicated installation and provides the convenience for users, developers and businesses, enabling the deployment of Internet of Things.

The proposed smart lighting is presented in **Figure 2.** There are three stages with different function.

Stage I: Led lamp, Led driver and RF node as shown in **Figure 3**. The function of Led driver is to control the illumination of the Led lamp. The power of Led driver is from 100W to 250W and it is can be dimmed. The function of RF node to transmit data.

In this paper, we used the LED driver which are integrated the smart control. The proposed LED driver is shown in **Figure 4,** which are two stage: AC/DC with PFC stage and DC/DC LLC resonant stage. The output current of this driver can be controlled based on control the second stage. Therefore, the luminaire of the LED can be adjusted. The nominal power of LED driver from 70W to 250W.

Stage II: Gateway as shown in **Figure 5.** The function of gateway is to measure and monitor the electrical parameter, lighting status, fault detection or remote management.

Stage III: Control center and data management as shown in **Figure 6**: the main parts of this stage are including server system, central management software. Remote management software collects and stores data securely and enables real-time communication with the entire system via a web interface with the following functions: store parameters and provide data; provide a user-friendly interface for operating personnel; control the status and lighting control system; analysis of accumulated data; make sure to create report documents; central control and management system; setting opacity via web interface; programming calendar dimming control from software; maintenance and alarm of system status.

The proposed smart lighting system is designed to control and monitor devices via wireless transmission frequencies below 1 GHz. The system will include many types of devices connected to each other by a gateway. The transmit distance is about 2km in the urban area and up to 5km in rural area. There are 2 main types of devices in the system including:

Controllable nodes: These nodes include controllable luminaires and electric cabinets. These devices can perform monitoring and remote control through the system administrator's web service

Monitoring nodes: Includes environmental sensors and power meters that update the system's real-time parameters to the control center. These sensors work to provide input parameters to perform automated control tasks

The luminaires can perform control through control schemes:

Mode 1: User control

The users with administrative rights can control the group of lights manually by drag the sliders and push the buttons to turn on, off or dim the group of lights

Mode 2: Timing control

The users with administrative rights can set the value of ON Time, On power, Timing 1, power 1, timing 2, power 2 to timing 5 power 5 and OFF time for each group of light. After setting and saving the timing table, the group of lights will automatically do the actions as programmed.

Mode 3: Auto control

The users with administrative rights can set the value of ON time, On power and off time for each group of lights

The user can active the "light sensors" function: When activing, the light can measure the light intensity to automatically change the value of ON time and OFF time to +- 3 hours depending on the season

The user can active the "local sensor auto dimming" function: The user will set the Timing and Power for the local sensor to take action. When this function is active, the individual light in the group can automatic control themselves by reading the value of the sensor then dim the light. The sensor will be use is motion sensor with an example bellow

On time: 7pm

Power on: 90%

Off time: 6am

Local sensor auto dimming time: 0h00

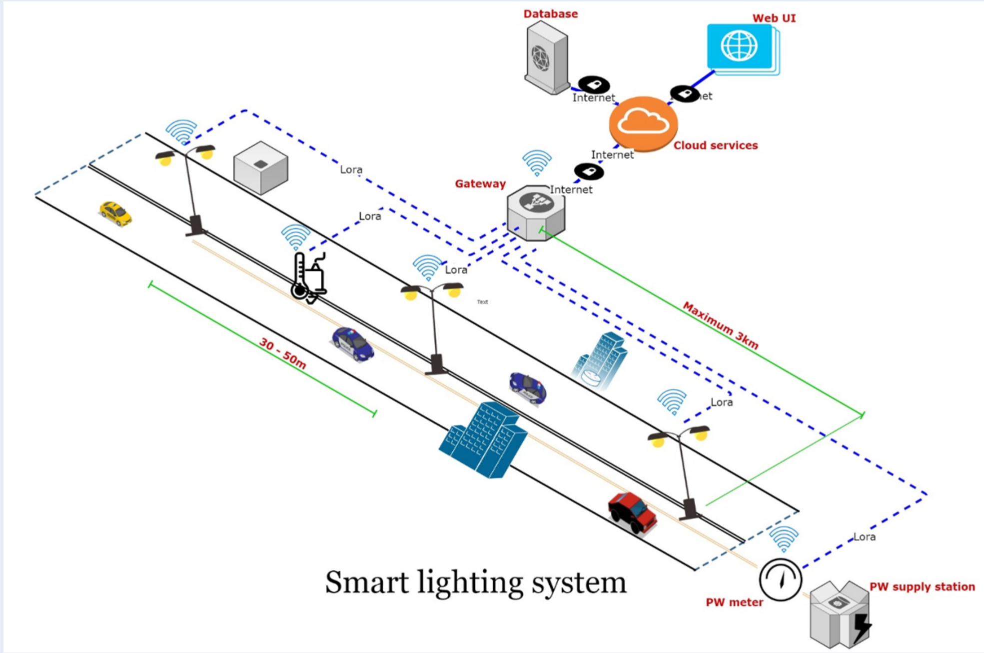

Figure 2: **The proposed smart street lighting.**

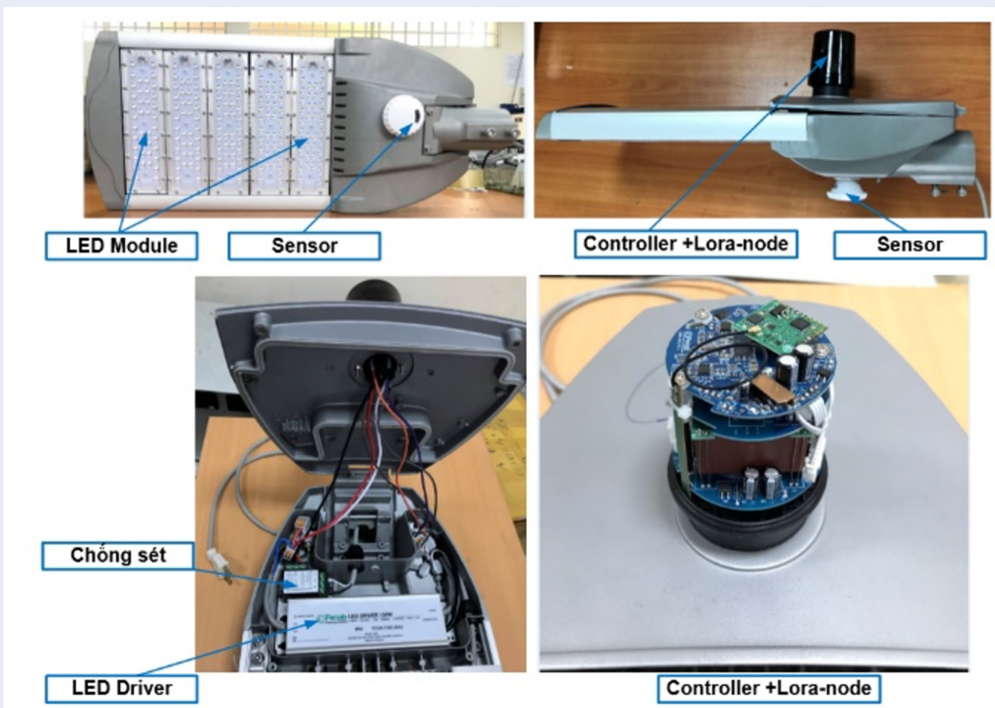

Figure 3: **The devices in Stage I.**

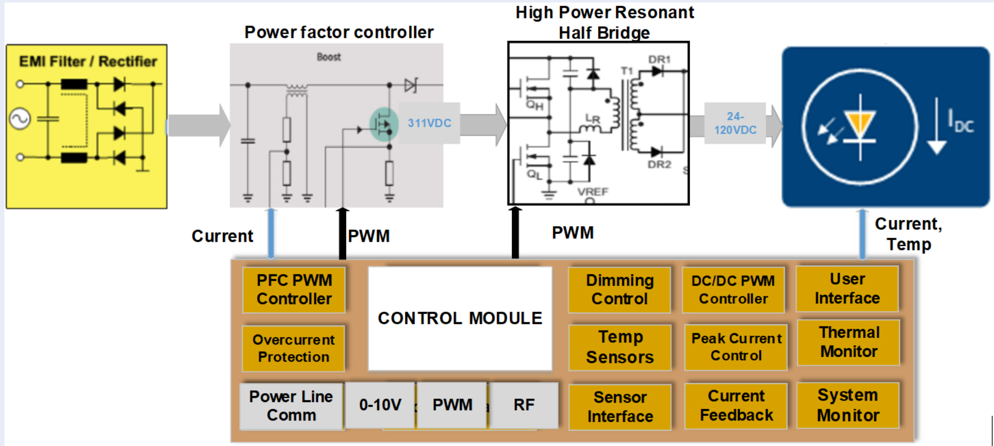

Figure 4: **LED driver used in experimental setup.**

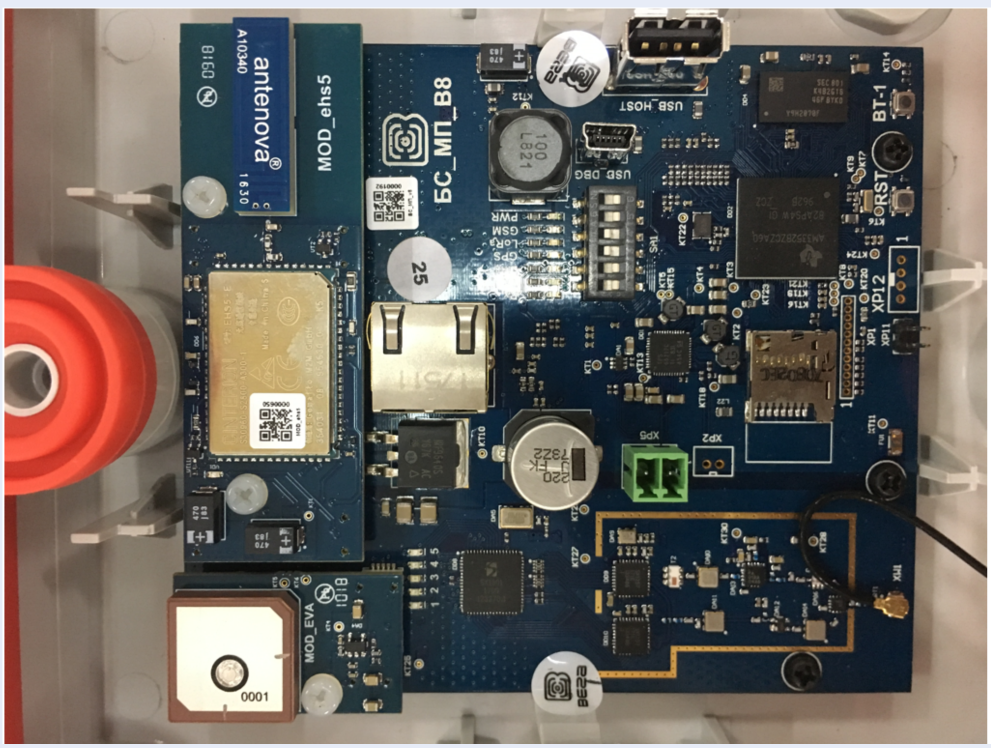

Figure 5: **Gateway– LoRa.**

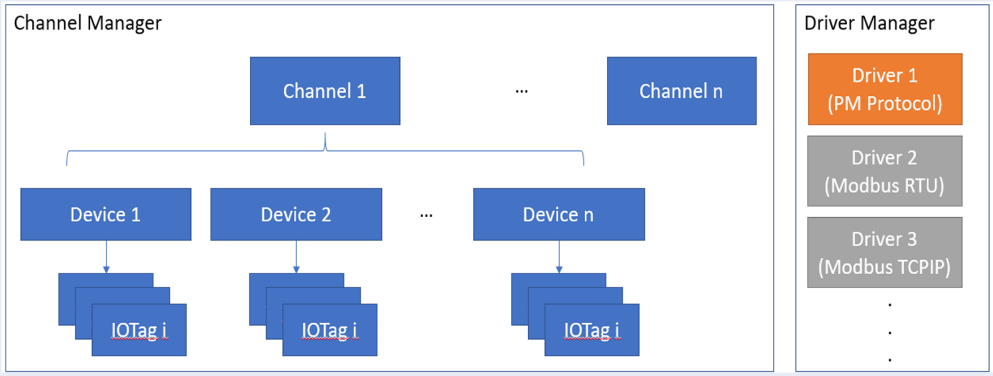

Figure 6: Control Center Software.

Power dimming: 70%

In this case, the group of lights will be turned on at 7pm with the power equal to 90% rated power. The motion sensors were deactivated

At 0h00 the group of light will active the motion sensors.

If there is a person below the light, the motion sensor is active and the light works at 90% rated power. If there is no person, the light will decrease the power to 70% rated power.

At 6h00 next day. The group of lights off.

The local sensor and the light will work independently, that means after setting up this mode, the web and server need not take any actions until next command (turn of the light).

A remote-control streetlight includes a wireless controller and a controllable led driver connected to each other via a smart control bus. The current and voltage at the input of the lamp are monitored by the controller while the load side output is controlled by internal MCU. These parameters were transmitted to the server via the remote gateway and data was synchronized in time thanks to the internal RTC inside the wireless controller. The smart control APIs on RS485 link were introduced to keep connect and control the led driver. At the same time, the driver is also capable of being controlled by da-li and analog in case of use with other controllers on the market.

THE EXPERIMENTAL RESULTS AND DISCUSSION

In order to verify the proposed system, we have built the smart lighting system in Hochiminh City University at shown in **Figure 7.** The lighting system structure is shown in **Figure 8**. In Led lamp, there are some control sets for on, off, dim and on, off, dim according to RTC. When the user controls the Led, the command comes down from the Web application - from the Web service from there to Gateway - Gateway sends the command down to the LoRaWan Module - and the module sends the command to the LED control set to execute the command. This process is a two-way process when the user sends the command down, the command must run back to get the response. Data from the LED control will switch to LoRaWan Module and Gateway to send to Cloud, network protocol is TCP. Each LoRaWan module has a unique MAC ID, so that Gateway can identify the data from which node is sent.

LoRa has two important parameters to assess the quality of the network when receiving the packet, which is RSSI- receiving signal strength indicator- indicating the signal strength received measured in dBm; is defined in the IEEE 802.11 standard. The greater the RSSI value, the greater the signal strength and SNR - signal-to-noise ratio (SNR) measured in dB. The quality of Lorawan network is determined by ARF8123AA handheld test and measurement device and is performed by moving the measuring device farther away than the Gateway, the results show that: at a distance of 4370 m RSSI value reached (-109dBm). According to experiment, in the range of RSSI (0;-137) dBm, all data can be fully transmitted in both directions. **Figure 9** shows the experimental results when we measure the quality of data transmission. It can be seen that the proposed system can be worked at 5 km radius region.

The software allows the distribution of system usage rights to users, with 3 classes: User, Admin and Super User. When clicking on a user, it will switch to a page with detailed information. The software allows users to manage the system: how many users and how many users are using an account. When we login to the system, we can see all the Led lamp in the map as shown

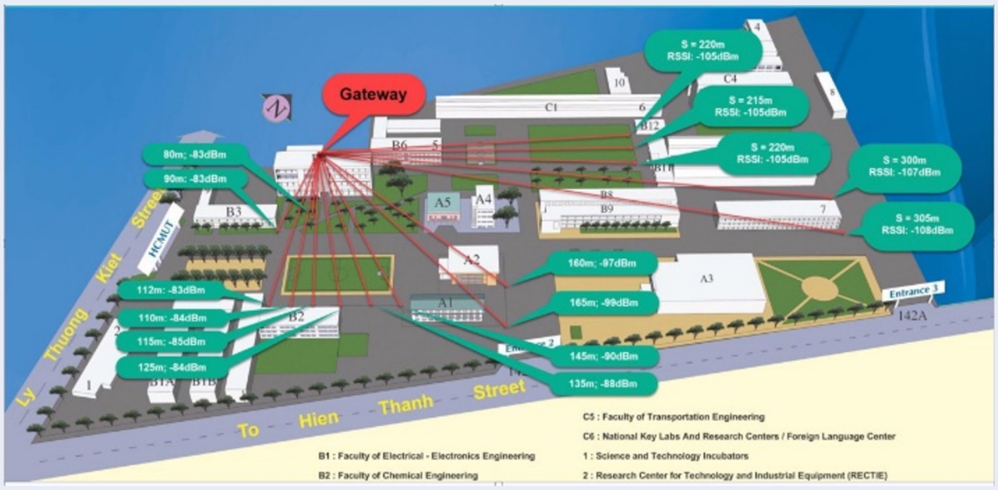

Figure 7: The installation of smart lighting system in HCMUT.

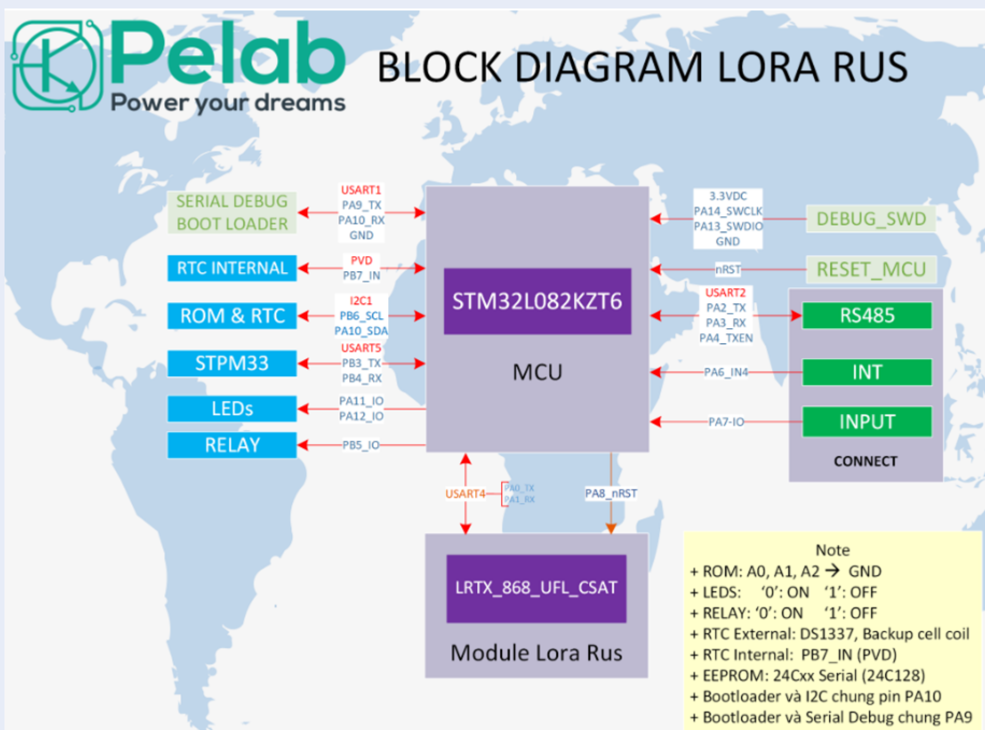

Figure 8: System structure.

Figure 9: **Experimental results.**

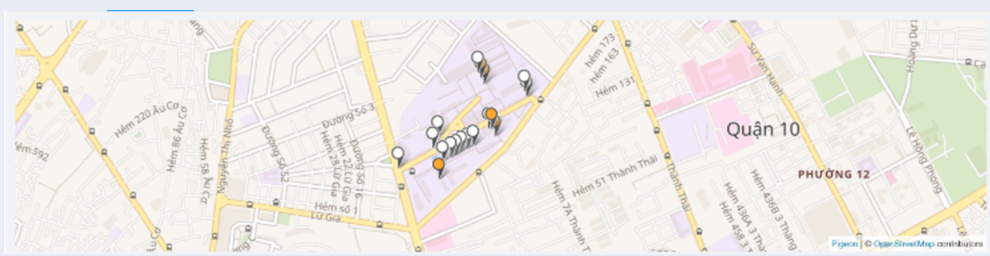

Figure 10: **Led lamp location in the map.**

in **Figure 10.** In this test, these lamps are divvied into three groups as shown in **Figure 11** and the number of lamps in each group are shown.

Figure 12and **Figure 13** shown the management function of this software. It can be seen that all data such as: dimming, input voltage, output current, power consumption, … are shown in the screen. **Figure 14** shows the status of each Led lamp, we can recognize the on/off status, and how much dimming.

CONCLUSION

The implementation of smart street lighting which is applied in Hochiminh City University is presented in this paper. LoRa Technology allows real-time analytics, sensing, reduced energy costs, and connectivity to the Cloud, all while continuing to keep citizens safe. And the Lora Wan techniques is used in this project. First, a LoRa-enabled sensor is embedded in a street lamp. Hence, these sensors have the ability to control the lamp's functions. A demonstration with 33 Led lamps (three groups) shows the effectiveness of the presented system.

ACKNOWLEDGMENT

This research is funded by Hochiminh City Department of Science and Technology under grand number: 18/2018/HD-SKHCN.

AUTHORS' CONTRIBUTIONS

Le Minh Phuong and Nguyen Dinh Tuyen designed the methodology and wrote the manuscript. Ngo Thanh Tung and Nguyen Minh Huy conceived and

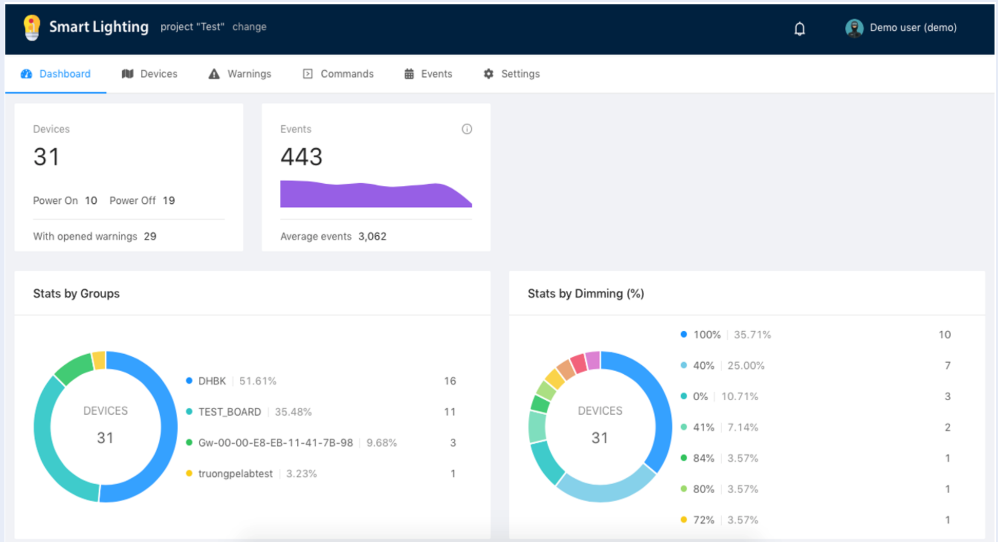

Figure 11: **Three lamp groups.**

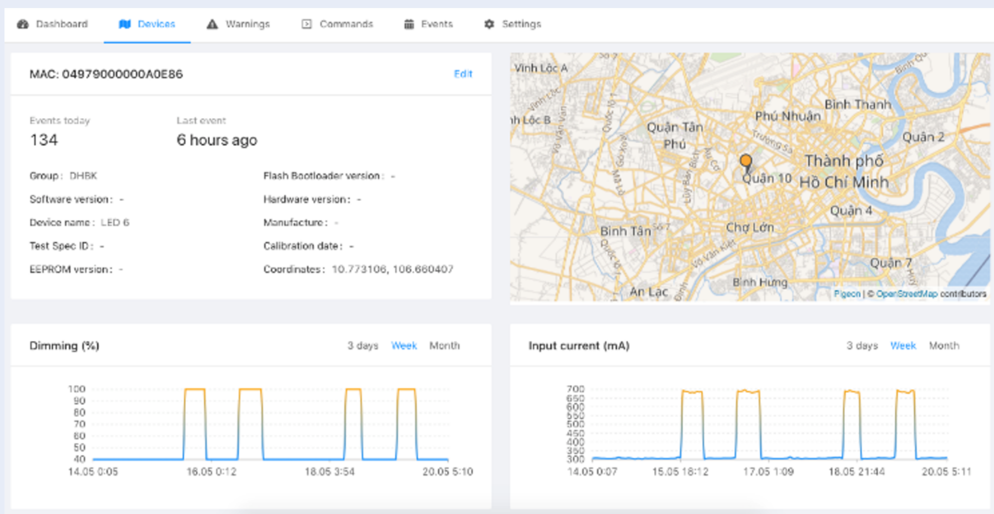

Figure 12: **Data management.**

designed the hardware. Ta Le Dinh Huy and Ngo Hoai Phong implemented the experiments and collected data. Le Minh Phuong provided supervision and manuscript revised.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

REFERENCES

1. Srivatsa DK, Preethi B, Parinitha R, Sumana G, Kumar A. Smart Street Lights. In: 2013 Texas Instruments India Educators' Conference. Bangalore, India: IEEE; 2013.
2. Bogdanov L, Polstra S, Yakimov P, Marinov M. DAEDALED: A GUI Tool for the Optimization of Smart City LED Street lighting Networks. In: 2018 IEEE XXVII International Scientific Conference Electronics - ET; 2018. p. 1–4. Available from: 10.1109/ET.2018.8549674.
3. Bhairi MN, Kangle SS, Edake MS, Madgundi BS, Bhosale VB. Design and implementation of smart solar LED street light. In: 2017 International Conference on Trends in Electronics and Informatics (ICEI); 2017. p. 509–512. Available from: 10.1109/ICOEI.2017.8300980.
4. Khalil HB, Abas N, Rauf S. Intelligent street light system in context of smart grid; 2017. Available from: 10.1109/ICCCNT.2017.8204158.
5. Yusoff YM, Rosli R, Karnaluddin MU, Samad M. Towards smart street lighting system in Malaysia. In: 2013 IEEE Symposium on Wireless Technolog & Applications (ISWTA); 2013. p. 301–305. Available from: 10.1109/ISWTA.2013.6688792.

Figure 13: Electrical parameters monitoring (a) Input voltage and power consumption (b) Consumption Energy.

6. Martín-Arias M, Huerta-Medina N, Rico-Secades M. Using wireless technologies in Lighting Smart Grids. In: 2013 International Conference on New Concepts in Smart Cities: Fostering Public and Private Alliances (SmartMILE); 2013. p. 1–6. Available from: 10.1109/SmartMILE.2013.6708206.
7. Huerta-Medina N, Corominas EL, Quintana PJ, Secades MR. Smart control for Smart Grids: From lighting systems to Grid side management; 2016. Available from: 10.1109/CIEP.2016.7530739.
8. https://rangdong.com.vn/.
9. SARR Y. B. GUEYE and C. SARR, "Performance Analysis of a Smart Street Lighting Application Using LoRa Wan. In: 2019 International Conference on Advanced Communication Technologies and Networking (CommNet); 2019. p. 1–6.
10. Muthanna MS, Muthanna MM, Khakimov A, Muthanna A. Development of intelligent street lighting services model based on LoRa technology. In: 2018 IEEE Conference of Russian Young Researchers in Electrical and Electronic Engineering (EIConRus); 2018. p. 90–93. Available from: 10.1109/EIConRus.2018.8317037.
11. CityTouch - Light management system, https://www.lighting.philips.com/main/systems/lighting-systems/citytouch.
12. Owlet IoT - The ultimate city management system, https://www.schreder.com/en/products/owlet-iot-smart-city-control-systems.
13. Street Light Control - Innovative light management system for outdoor areas, https://www.osram.com/ds/knowledge/street-light-control-by-osram-innovative-light-management-system-for-outdoor-areas/index.jsp.

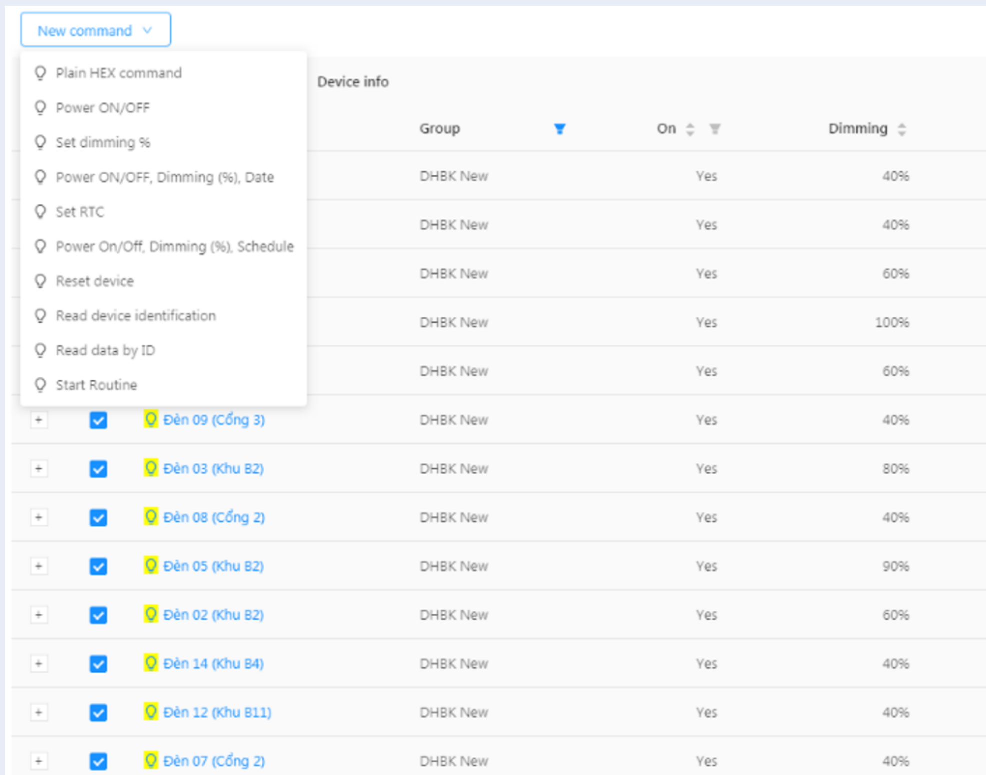

Figure 14: The status of each Led lamp.

Science & Technology Development Journal – Kĩ thuật và Công nghệ, 2(3):193-206

Open Access Full Text Article

Bài Nghiên cứu

Phát triển và thực thi hệ thống chiếu sáng đường phố thông minh trên cơ sở công nghệ LoRa

Ngô Thanh Tùng[1], Nguyễn Hoài Phong[2], Tạ Lê Đình Huy[3], Nguyễn Minh Huy[3], Nguyễn Đình Tuyên[3], Lê Minh Phương[3,*]

TÓM TẮT

Bài báo này trình bày sự thực thi hệ thống chiếu sáng thông minh dựa trên đèn Led và hệ thống truyền không dây LoRa. Các đèn đường thông minh đã được phát triển gần đây và các công nghệ này đã đóng một vai trò quan trọng trong an toàn đô thị, tiết kiệm năng lượng. Hiện tại, đèn đường sẽ tự động bật, tắt dựa trên bộ hẹn giờ hoặc cảm biến ngày đêm. Trong bài báo này, hệ thống chiếu sáng thông minh được đề xuất để thay thế hệ thống chiếu sáng cũ để điều khiển và giám sát các thiết bị thông qua hệ thống truyền không dây với tần số dưới 1 GHz. Đèn Led hiện đang được thay thế cho các đèn truyền thống và các điều khiển thông minh ngày càng được sử dụng nhiều hơn và phát triển song song với sự phát triển của đèn Led. Đèn Led có rất nhiều ưu điểm như: tiết kiệm năng lượng, tuổi thọ cao, độ tin cậy cao, ánh sáng trung thực, và thân thiện môi trường. Hơn nữa, việc điều khiển độ sáng của đèn Led cũng dễ dàng hơn so với các đèn khác. Hệ thống chiếu sáng thông minh trong bài báo được xây dựng dựa vào nhiều thiết bị được kết nối với nhau thông qua thiết bị Gateway. Khoảng cách truyền dữ liệu khoảng 2 km ở khu vực thành thị và 5 km ở khu vực nông thôn. Hệ thống chiếu sáng đề xuất trong bài báo có các tính năng hoạt động như: chế độ tự động, chế độ điều khiển từ xa, chế độ ngắt kết nối lưới, chế độ vận hành trực tiếp bằng tay. Hệ thống chiếu sáng này đã được thực hiện tại Trường Đại học Bách khoa, ĐHQG-HCM và các kết quả thực nghiệm được đo đạc để chứng minh tính khả thi của giải pháp đề xuất.

Từ khoá: chiếu sáng sử dụng LED, Chiếu sáng thông minh, Thành phố thông minh, Công nghệ LoRA

[1]*Trường ĐH Thông tin Liên lạc*

[2]*Trường ĐH Công nghiệp TP.HCM*

[3]*Trường ĐH Bách khoa, Đại học Quốc gia TP.HCM*

Liên hệ

Lê Minh Phương, Trường ĐH Bách khoa, Đại học Quốc gia TP.HCM

Email: lmphuong@hcmut.edu.vn

Lịch sử

- Ngày nhận: 28-8-2019
- Ngày chấp nhận: 21/9/2019
- Ngày đăng: 30/9/2019

DOI : 10.32508/stdjet.v2i3.570

Trích dẫn bài báo này: Tùng N T, Phong N H, Huy T L D, Huy N M, Tuyên N D, Phương L M. **Phát triển và thực thi hệ thống chiếu sáng đường phố thông minh trên cơ sở công nghệ LoRa** . *Sci. Tech. Dev. J. - Eng. Tech.;* 2(3):193-206.