Jurnal Teknologi

Full Paper

ENERGY-SAVING STREET LIGHTING SYSTEM BASED ON THE WASPMOTE MOTE

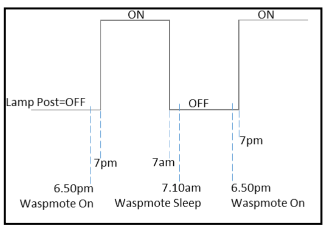
L. H. Adnan*, Y. M. Yussoff , H. Johar, S. R. M. S. Baki

Centre of Computer Engineering Studies, Faculty of Electrical Engineering, Universiti Teknologi MARA, Shah Alam, Malaysia

Article history
Received
31 January 2015
Received in revised form
30 April 2015
Accepted
31 May 2015

*Corresponding author
lukmanhakim85@yahoo.com.my

Graphical abstract



Abstract

Energy-saving street lighting (ESSL) system is one of the promising approach to support smart city in the future. The technology that evolves with the advance in low energy microcontroller and wireless communication has become the foundation in the development of ESSL system. This paper presents initial development for ESSL system focusing on the Malaysia environment. The system utilizing Waspmote as a main part of sensor node, zigbee for communication and PIR sensor for motion detection. Deployment of sensor node at real environment also been discussed in this initial development. The sensor node can be used to control the brightness of the street light and the developed system found to save energy through the switching method of street light.

Keywords: Energy-saving street lighting system, green technology, smart cities, wireless sensor network

1.0 INTRODUCTION

Smart cities and green technology has becoming one of the direction of the world in preparing for better future, and one of the element to support these smart cities is energy-saving street light (ESSL) system. Previous traditional street light system may have neglected the emission of Carbon Dioxide (CO2) in the design thus has exposed the world to environmental issues which is climate change. Acknowledging the important of controlling the emission of CO2, ESSL system is introduced to cater this problem thus to support one of the smart cities elements.

The key element for the ESSL system may include high efficiency fixtures and automated controls that make adjustments based on conditions such as occupancy or daylight availability and ability to produce report to the user.

Apart from supporting toward better future, ESSL technologies also allow improvement in the area of response and maintenance where failures or breakdowns within the deployment area are almost real time detectable, allowing immediate response from the respective person or agencies. Some of ESSL system in the market are EkoLum [1], LorenNetworks [2] and OSRAM [3].

Studies on the innovation of street lighting include type of lamp [4] [5], alternate the power source to solar (photovoltaic - PV) [5, 6] and wind [7, 8], and improve the technique by using sensor [9, 10]. The initial development for this project [11] also show that energy on street light can be reduced up to 40% with PWM technique. This paper will expand from the initial development [11] by implementing scenario and specification from site project to in-lab implementation.

2.0 WIRELESS SENSOR NODE

Wireless Sensor Node (WSN) is a small electronic device consist of microcontroller, RF transceiver and sensor. These nodes can communicate with each other and form a network to provide monitoring data [12]. New trend in WSN is that this device are no longer simple sensor node such as temperature, pressure, humidity sensor but offer wide range of control signal compatible with different application and environments. Through random deployment at any places, WSN has closing the gap between real world environment and digital world.

3.0 BACKGROUND

Conventional street light used High Pressure Sodium (HPS) as a lamp type and already established. New type of lamp that been introduced in this area is using LED, and this type of lamp give a lot of energy saving to the user/local authority. Although the LED already used lower power consumption compared to HPS light [13] [14], but in certain places, these power consumption (LED type used) still can be further reduced due to the environment or places. For example at certain parking lot area, when reached at the certain time, this place does not require full brightness from street light or only have light when there is a motion.

In this research, few specification for the project are identified as a framework and limitation so that the project met the goal and comply with the safety of road user and government/private policies [15].

The framework as below:

a) To reduce power consumption and emission of CO2 for LED base street light
b) To comply with Malaysian Standard (MS) in term of safety and security of street light

The limitation as below:

a) Implementation of this research is conducted in a laboratory for testing purposes.
b) Actual street light hardware are used, but the lumen of the hardware are not measured in this implementation.
c) The work performed is related to test the functionality of switching module.

Based on the framework and limitation above, this research work together with Pejabat Pengurusan Fasiliti UiTM [16] Shah Alam has identified suitable site to implement the project. The site project are located at Jalan Sarjana 1/2 near Gate 3 UiTM Shah Alam which has installed with 22 LED base street light. The distance between street light are about 22 meter and the height for each is 7 meter to ground and all lamp post power are controlled by one feeder pillar. Type of LED that used at this site; which is 2 LED module per lamp and support by 2 driver to drive the LED. Each driver of LED used 240v as input feed and generate 80w of power consumption. All the lamp posts are working on 12 hour cycle; 7pm-7am ON cycle and 7am-7pm OFF cycle and controlled by timer inside the feeder pillar.

4.0 METHODOLOGY

To achieve the best result, the project was separated into four parts which is site planning and simulation, hardware design, sensor node operation and deployment.

a) **Site Planning:** This Jalan Sarjana 1/2 are chosen for analysis, as the traffic decreased to 40% when reaching midnight and completely no traffic on this street on the next 7 hours. Due to this situation, power consumption for each of this street light can be reduced if the brightness of LED are controlled. Malaysian regulation are outline the specification for brightness of street light: cannot completely turn OFF the street light in any situation even in zero traffic condition [17].
b) **Hardware Design:** The hardware consist of Waspmote [18] as main part of sensor node, power module, battery module for backup, zigbee module for communication, PIR sensor for motion detection [19] and switching module to control LED . Switching module are connected to one of the LED driver module to control the LED brightness.
c) **Sensor Node Operation:** Sensor node system are working in 12 hour cycle. Although it came with the battery pack, but the lamp post are operation at 12 hour cycle, the sensor node operation also need to tally with this operation because main power supply for sensor node came from the lamp post.
d) **Deployment:** The location is at Jalan DATC in UiTM and only one sensor node has been deployed at the street light. Focus for this deployment is to measure the endurance and abilities of sensor node in real environment. The sensor node equipped with movement sensor and deployed for a week, and the parameter that been measure by the sensor node is movement at the road. The sensor node will detect movement at this road for every second on 12 hour cycle, and;

Movement at the road [MTR] = '1'
No movement at the road [xMTR] = '0'

$$\frac{[MTR]}{[MTR] + [xMTR]} \times 100 = \text{Percentage of road used} \quad (1)$$

The data will be stored in the sdcard and the measurement will start at 7pm and ended at 7am next day. Then, this parameter will be translated to percentage of road used [Eq.1].

5.0 RESULTS AND IMPLEMENTATION

There are few data that been measured in this implementation such as current before and after switching. Table I illustrates the data read in the implementation. First data is the current before and after the sensor node are installed on the LED, if there is an increment or not. The data shows that there is no increment after installation on the sensor node. The sensor node system consume 20m amp only to operate, giving little impact to the LED. Second data is the current in the switching mode (ON or OFF). Before switching "OFF mode", current reading is 0.3 amp for LED, this shows that the sensor node system successfully control the LED driver. After switch to "ON mode", the current reading is 0.6 amp.

Table 1 Data read in the implementation

Node	**Current (Amp)**	
	Before Sensor Node Installed	After Sensor Node Installed
	0.6	0.6
	Switching	
	OFF	ON
	0.3	0.6
LED	20mA	

Figure 1 shows the timeline for sensor node operation. Sensor node will start to operate at 6.50pm every day until 7.10am on the next day, then will placed in sleep mode until reach the next 6.50pm. This technique able to save the battery life for the sensor node as when lamp post in the OFF cycle, the sensor node is in the sleep mode. Power consumed for sensor node in sleep mode only 1m Watts, this able to reduce the power consumption for the system.

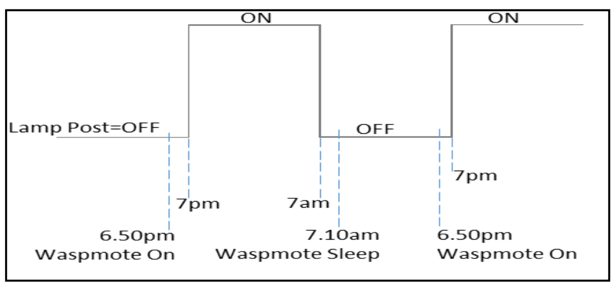


Figure 1 Timeline for sensor node operation

Figure 2a shows the deployment result by day for a week. From the data [Figure 2a], it is found out that average road usage on 12 hours cycle is 5% on the 5 days, meaning that's only 0.6 hours from 12 hours that this road is used, another 11.4 hours are not in use . For 4 and 6 Sept, heavily raining detected in this day, thus give effect to the result on this day. The data then being broken down into 4 quarter [Figure 2b], quarter 1 [7pm-10pm], quarter 2 [10pm-1am], quarter 3 [1am-4am] and quarter 4 [4am-7am] to analyze more on peak hour and zero movement hour on the road.

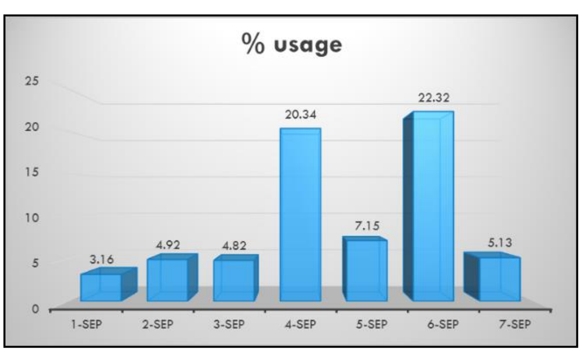


Figure 2a Deployment result for a week - by day

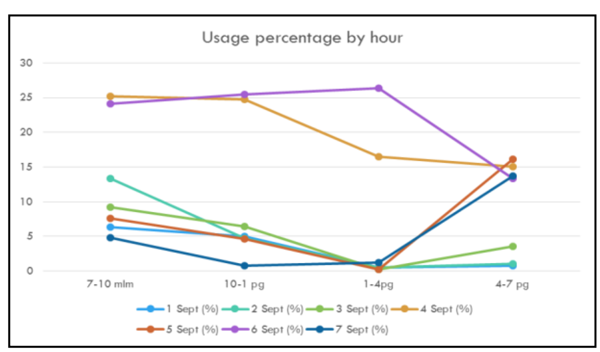


Figure 2b Deployment result for a week - by hour

6.0 CONCLUSION

This paper presents in-lab implementation for ESSL system. Although the implementation is done in the lab, actual LED are used to obtain actual reading such as input current, functionality of sensor node are test with 12 hour ON-OFF cycle and also deploy the sensor node at real environment to test the endurance and abilities of the sensor node. By controlling the LED driver module, brightness of the LED can be controlled using sensor node with no increment in the total power consumption in the LED base street light. In future, this system will integrate with current sensor to give real time current reading at the lamp post and integrate with database system for triggering maintenance system. Security features also will included in the next phase of the system to protect the data in the future.

Figure 2a shows the deployment result by day for a week. From the data [Figure 2a], it is found out that average road usage on 12 hours cycle is 5% on the 5 days, meaning that's only 0.6 hours from 12 hours that this road is used, another 11.4 hours are not in use . For 4 and 6 Sept, heavily raining detected in this day, thus give effect to the result on this day. The data then being broken down into 4 quarter [Figure 2b], quarter 1 [7pm-10pm], quarter 2 [10pm-1am], quarter 3 [1am-4am] and quarter 4 [4am-7am] to analyze more on peak hour and zero movement hour on the road.

The average usage of this road is at quarter 1, which give 5-14% usage, then slowly decrease when enter quarter 2 [1-7% road usage]. The use of the road falls to its lowest when enter into the third quarter, below 3%, then slowly increase when enter to quarter 4. The a-week data above shows that sensor node can withstand the real environment with the 12 hours cycle of street light system. Although the data reading for 2 days from the sensor node not accurate because of the heavy raining, but this proof show that the sensor node can withstand in the extreme condition.

Acknowledgement

This work was supported in part by grant from Universiti Teknologi Mara (UiTM).

References

[1] EkoLum Smart Street Lighting Solution Street Light Monitoring Software retrived April, 19, 2013 from http://www.ekolum.com/.

[2] Loren Networks retrieved April 19, 2013 from http://www.lorennetworks.com/.

[3] Hu, W., Corke, P., Shih, W. C. and Overs, L. 2009. *SecFleck: A Public Key Technology Platform for Wireless Sensor Networks*. LNCS Cork, Ireland: Springer Verlag. 5432: 296-311.

[4] OSRAM SSL LED Lighting the Future retrived April,19,2013 from http://ledlight.osram-os.com/farther/?gclid=CNjr-sm81bYCFVEk6wodm34AHw.

[5] Alzubaidi, S. and Soori, P. K. 2012. Study on Energy Efficient Street Lighting System Design. *Power Engineering and Optimization Conference (PEDCO) Melaka, Malaysia, IEEE International*. 291-295.

[6] Nunoo, S., Attachie, J. C. and Abraham, C. K. 2010. Using Solar Power as an Alternative Source of Electrical Energy For Street Lighting In Ghana. *IEEE Conference on Innovative Technologies for an Efficient and Reliable Electricity Supply*. 467-471.

[7] Rahman, H. A., Hassan, M. Y., Majid, M. S., Nor, K. M. and Atan, N. A. 2008. Economic Study on the Effectiveness of Photovoltaic Street Lighting in Universiti Teknologi Malaysia. *12th International Middle-East Power System Conference*. 624-629.

[8] Georges, S. and Slaoui, F. S. 2011. Case Study of Hybrid Wind-Solar Power Systems for Street Lighting. *21st International Conference on Systems Engineering*. 82-85.

[9] Bouroussis, C. A., Georgaris, I. and Topalis, F. V. Outdoor Lighting Using Renewable Energy Sources. *6th WSEAS International Conference on Power Systems, Lisbon, Portugal*. 72-77.

[10] Leccese, F. and Leonowicz, Z. 2012. Intelligent Wireless Street Lighting System. *11th International Conference on Environment and Electrical Engineering*. 958-961.

[11] Wang, K. and Liu, S. 2007. A Sensor Integrated Ultra-long Span LED Street Lamp System. *Electronic Packaging Technology, ICEPT, 8th International Conference*. 1-3.

[12] Yusoff, Y. M., Rosli, R., Karnaluddin, M. U. and Samad, M. 2013. Towards Smart Street Lighting System in Malaysia. *Wireless Technology and Applications Symposium (ISWTA) Sarawak. IEEE Internationa*. 301-305.

[13] Bhaskar, K. 2005. *Networking Wireless Sensors*. Cambridge University Press 2005.

[14] Outdoor Area Lighting retrived April 19,2013 from http://apps1.eere.energy.gov/buildings/publications/pdfs/alliances/outdoor_area_lighting.pdf.

[15] DMX LED Street Lights - LU1 retrieved April 19,2013 from http://www.dmxledlights.com/OutdoorLighting/StreetLightsLU1/Comparison_HPS_vs_LED_Street_Lights.html.

[16] MS 825 Part 1 retrived August 11, 2014 from http://www.standardsmalaysia.gov.my.

[17] Pejabat Pengurusan Fasiliti UiTM retrived August 11, 2014 from http://ppf.uitm.edu.my/.

[18] ADDENDUM NO. 1: REVISION 1 TO L S20 SPECIFICATION FOR ROAD LIGHTING INSTALLATION-August-1999.pdf retrived April,19,2013 from https://jmal.jkr.gov.

[19] Guide, T. - Waspmote Technical Guide wasp mote retrived April 19, 2013 from http://www.libelium.com/uploads/2013/02/waspmote-technical_guide_eng.pdf.

[20] Description, G. Ideas, A., Circuit, Q. S. and Dimensions, M. - PIR Sensor (# 555-28027). Retrived April 19, 2013 from http://www.parallax.com/Portals/0/Downloads/docs/prod/sens/555-28027-PIRSensor-v2.1.pdf.