Automatic Street Light Control System using Wireless Sensor Networks

Dhiraj Sunehra, SMIEEE
Department of Electronics & Communication Engineering
JNTUH College of Engineering
Jagtial-505501, Telangana, India
dhirajsunehra@yahoo.co.in

Sangem Rajasri
Department of Electronics & Communication Engineering
JNTUH College of Engineering
Jagtial-505501, Telangana, India
rajasrisangem@gmail.com

***Abstract*—Energy consumption due to the street lights needs proper monitoring and control to reduce wastage of power. Conventional street light systems suffer from certain drawbacks as they are manually controlled and are powered through the electrical board power station. This may lead to more power consumption if not monitored properly. In this paper, an automatic street light control system is implemented based on wireless sensor networks (WSN). The street lamp post forms the WSN node. It uses an Arduino Uno board and various sensors to detect traffic on the road. A Raspberry Pi3 computer is used as a web server at the central base station to monitor the status of the street lights. The lights are turned on based on the sensor signals only during nighttime and when traffic is present. A webpage is developed using HTML and PHP language for uploading the sensor data and web control of the street lights. Solar cells are used at each node to power on the street lights.**

Keywords—Wireless Sensor Network; Automatic Street light control; Webbased Control; Sensors; Solar power

I. Introduction

A Wireless sensor network (WSN) consists of various sensor nodes that transmit sensor information among other nodes in the network and to a central node. In this investigation, a WSN architecture is used to implement an automatic street lighting system. Each street lamp post is designed as a node. The sensors at each node collect data regarding the traffic conditions, day or nighttime information, current, etc. and transmit to the central base station. The street lamp post uses LED lights and solar cells to help reduce power consumption. The street lights are turned on or off according to the presence of traffic. The base station is used as a web server, which uploads the sensor information and status of lights turned on or off on to the developed web page. The various sensors used include light dependent resistor (LDR), ultrasonic sensor, and a passive infrared (PIR) sensor.

II. Literature Survey

Buratti et al presented a survey of various WSN technologies, design aspects and evolutions [1]. Swathi and Manoj have used the GSM technology to monitor and control the street lights. Use of GSM enables ease of fault detection and repair as information is sent to nearby control terminal [2]. Shahzad et al have proposed a traffic flow based LED lighting system with adjustable illumination for improving the energy efficiency [3]. Fabiolecces proposed a high efficient automatic streetlight system using ZigBee networks. WSN is used to transform the information between lamp post and base station [4]. Liuyi Ling et al developed a photovoltaic cell and microcontroller based intelligent LED street light system. A wireless communication module is used to remotely operate and control the dimming of LED lights [5].

III. Block Diagram and Description of Hardware

Figure 1 shows the block diagram of automatic street light control system using WSN. It consists of lamp stations and a base station. Each lamp station consists of Arduino Uno board as microcontroller, PIR sensor, emergency switch, LDR sensor, nRF24L01 transceiver, ultrasonic sensor, relay, LED light and a solar panel as energy source. The base station consists of Raspberry Pi as processor, nRF24L01 transceiver, and a GSM module.

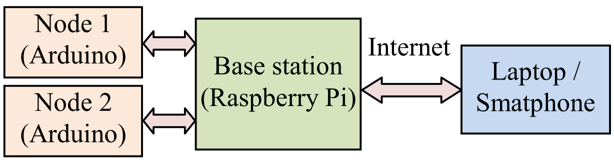

Fig.1 Block diagram of Automatic Street light Control System using WSN

The automatic street light turns on under three conditions. Firstly, when PIR sensor detects a human or a moving object (vehicle), LED light is turned on. Secondly, an ultrasonic sensor is used to detect distance objects and turn on the light accordingly. Lastly, a switch is included for manual operation in case of maintenance work. The LDR sensor is included to measure the light intensity, for identification of day and night. The nRF24L01 wireless transceiver transmits the sensor information and the light status to the Raspberry web server to upload on the webpage. Also, it receives commands sent from the webpage to turn on or off the light at a particular node. The entire system is powered using solar cells, making it more energy efficient. This system is a traffic aware system.

978-1-5386-0814-2/17/$31.00 ©2017 IEEE

Raspberry Pi3 Model B is a small single board minicomputer. It has a 1.2 GHz Quad-Core Cortex-A53 Broadcom BCM2837 64-bit ARMv8 processor [6]. It has 40 pins for GPIO and RAM of 1GB (Fig. 2).

Fig. 2. Raspberry Pi3 Model B Board

The passive infrared (PIR) sensor is used to detect human beings or surrounding objects as passive radiations. It can detect a person up to approximately 30 ft. away [7]**.** Figure 3 shows the PIR sensor.

Fig. 3 PIR sensor

A light dependent resistor (LDR) sensor can measure the intensity of the sunlight and its operation is based on the change in resistance with incident light. It measures the light intensity, for identification of day and night. Figure 4 shows the LDR sensor.

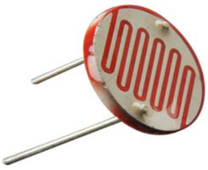

Fig. 4 LDR sensor

A current sensor is used measure electric current either AC or DC (Fig. 5). The generated signal could be analog voltage or current. It can be used to display the current in an ammeter or can be utilized for control purpose.

Fig. 5 Current sensor

An ultrasonic sensor is used to detect objects which are at a distance ranging from 2 cm-4 m (Fig. 6). It has an operating voltage of 5V (DC), working current of 15mA, measuring angle of 15°, and dimensions of 16 x 50 mm [8].

Fig. 6 Ultrasonic sensor

The nRF24L01wireless transceiver can be used as both transmitter and receiver (Fig. 7). In this system, two nRF24L01 transceivers are used. It is a 2.4 GHz transceiver, data rate of 2 Mbps. It has automatic packet handling. It requires supply voltage of 1.9 to 3.6 V [9].

Fig. 7 nRF24L01 Wireless Transceiver

Arduino Uno is a microcontroller board based on 8-bit ATMega328P microcontroller. It has 14 digital I/O pins and 6 analog inputs (Fig. 8). The board has a SRAM of 2KB, EPROM of 1KB, USB connection, RESET button and CPU speed of 16 MHz [10].

Fig. 8. Arduino Uno Board

A GSM modem is used for communication between the Raspberry Pi computer and the GSM/GPRS network. Figure 9 shows the SIM900A GSM modem. It requires a SIM card to activate communication with the network. A GSM modem can send and receive a SMS and voice call. This modem can interact with processor or controller using AT commands, which are sent by the controller serially [11].

Fig. 9 SIM 900A GSM Modem

IV. EXPERIMENTAL SETUP

Figure 10 shows the experimental setup of Arduino based street light WSN node. Each node includes various sensor modules interfaced to the Arduino board and a wireless communication transceiver. The various sensors used are PIR sensor, LDR sensor, ultrasonic sensor, and current sensor. A solar panel is used to power on the LED lights. The nRF24L01 wireless transceiver is used to transmit the sensor information from the Arduino node to the Raspberry Pi web server and also receive commands from Raspberry Pi webserver for manual street light control.

Python language is used to write the software code for Raspberry Pi. It has an automatic memory management and a standard library. Raspberry Pi is login by using ExtraPuTTY software. Python code is dumped into Raspberry Pi board. Router is used to configure the Raspberry Pi. The IP address is entered in the PuTTY software. Figure 11 shows the PuTTY window for Raspberry Pi board initialization.

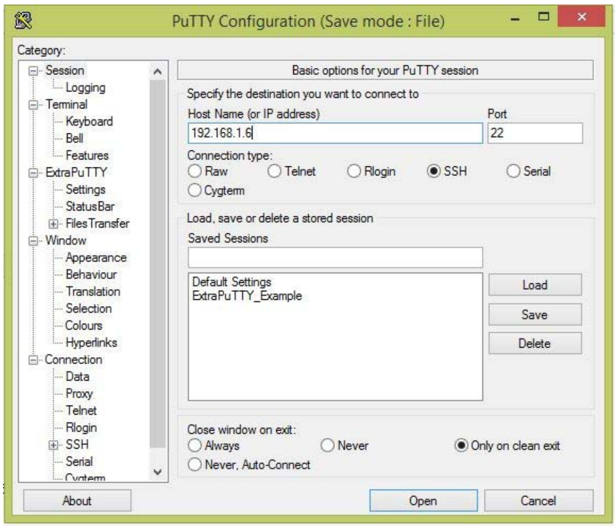

Fig.11 Raspberry Pi board initialization

Figure 12 shows the experimental setup of Raspberry Pi web server side (base station). It includes the Raspberry Pi, nRF24L01 module, USB to serial interface, and GSM module. The base station receives the information from nRF module and uploads on the web page. The GSM module is used to send an alert message to the concerned officials when the current increases above the rated value. For automatic operation, street lights will turn on/off based on sensor values. We can also control the lights through the web page.

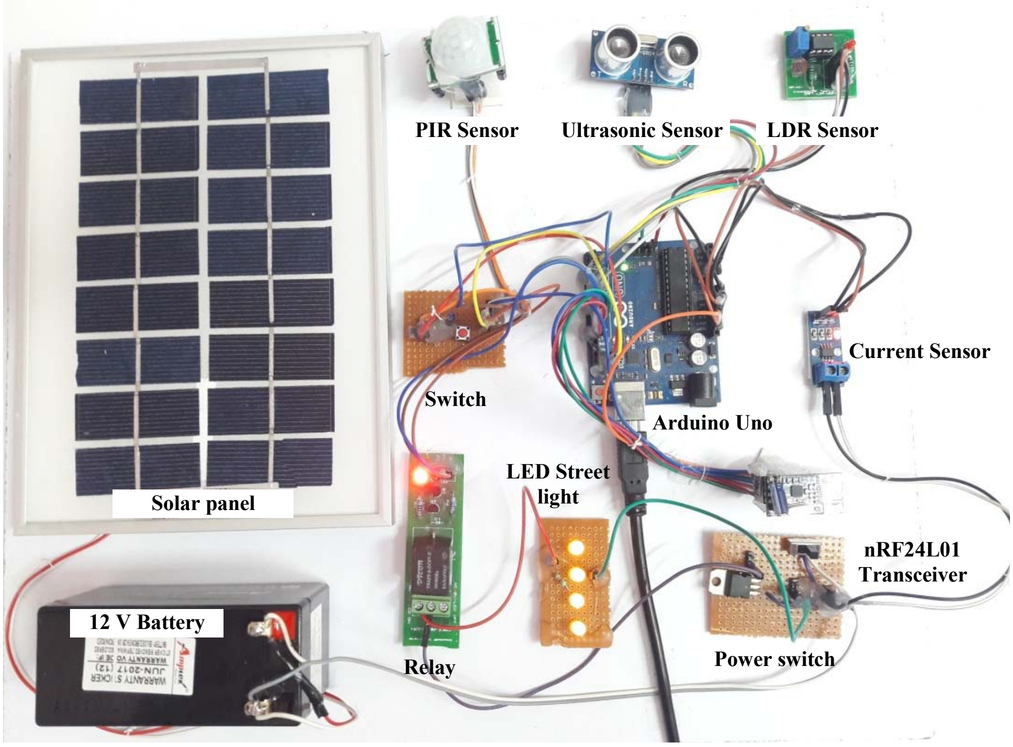

Fig.10 Experimental Setup of Arduino based LED Street light node with lights Turned on

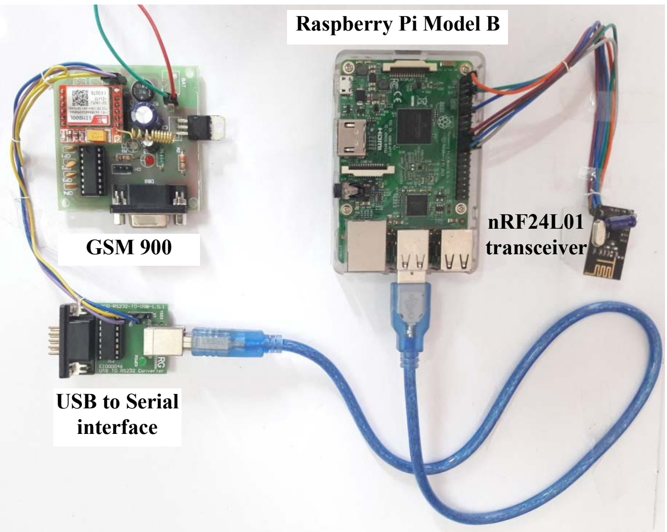

Fig.12 Experimental setup of Raspberry Pi web server (base station)

V. Results and Discussion

The sensor outputs received from various nodes are uploaded on to the web page. Figure 13 shows the snapshot of the main web page developed using PHP. This has various options such as sensor data, data from node 1, data from node 2 and device control. Sensor data gives status of all nodes along with date and time stamp, as shown in Fig. 14. It includes PIR status, object distance measured by ultrasonic sensor, emergency switch status, LDR status and Current at each node. On clicking device control on the main webpage, various switch options to select the manual operation for light 1(2) ON or OFF, All devices on, All devices off, are displayed as shown in Fig. 15. If any button is pressed, corresponding operation is executed and the status is displayed on the web page as shown in Figs.16-17.

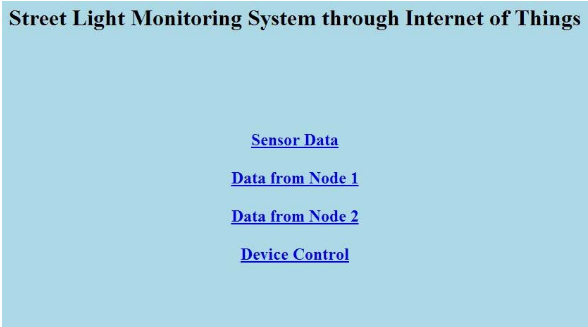

Fig. 13 Snapshot of the Main page of the Automatic Street Light System

Automatic Street Light Management System using WSN

S.No	Node1_PIR	Node1_Dist	Node1_Emer	Node1_LDR	Node1_Current	Node2_PIR	Node2_Dist	Node2_Emer	Node2_LDR	Node2_Current	Date and Time
1	0	0	0	1	126	1	4	1	1	127	2017-07-02 13:27:27.134025
2	0	0	0	1	126	0	3	1	1	127	2017-07-02 13:27:17.043824
3	1	0	1	1	126	0	5	1	1	127	2017-07-02 13:27:09.673947
4	1	0	1	0	127	0	193	1	0	127	2017-07-02 13:27:02.663072
5	0	12	1	1	126	0	0	0	1	128	2017-07-02 13:26:55.652179
6	0	0	1	0	127	0	0	1	0	127	2017-07-02 13:26:48.640908
7	0	0	0	1	126	0	0	1	0	127	2017-07-02 13:26:41.630202
8	0	0	1	0	126	0	196	1	0	127	2017-07-02 13:26:34.621216
9	0	0	1	0	126	0	0	1	0	127	2017-07-02 13:25:24.757721
10	0	0	1	0	126	0	0	1	0	127	2017-07-02 13:25:14.543238

Fig. 14 Snapshot showing various sensor parameters displayed on webpage corresponding to each node along with date and time stamp

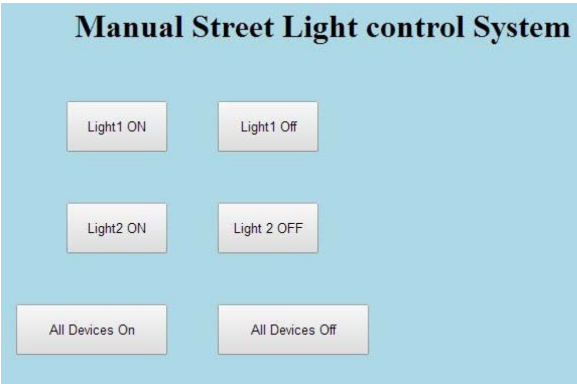

Fig. 15 Snapshot of Web page showing various buttons for Manual street light control through webpage

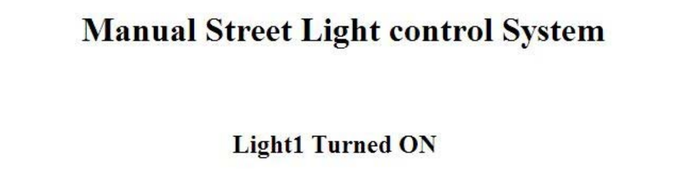

Fig. 16 Snapshot showing status on webpage when Light 1 is turned ON

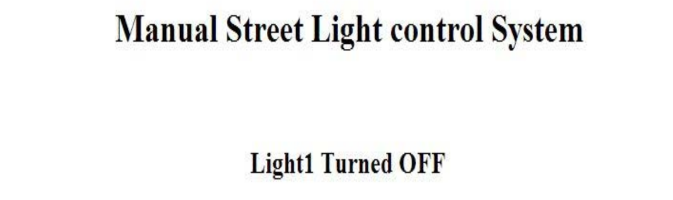

Fig.17 Snapshot showing status on webpage when Light 1 is turned OFF

When the current in the circuit at a particular node increases above 250 mA, an SMS is sent to the concerned indicating some malfunctioning in the system.

VI. Conclusions

In this paper, a web based intelligent street light system using WSN concept is implemented. The lamp station includes various sensors. These sensors sense the surrounding objects based on which the lights are turned on or off. This system helps in reducing wastage of power as it is adaptable to traffic conditions. It can also be controlled manually through the webpage. The developed webpage allows monitoring the status of each street lamp post and helps in repair and maintenance, if any node goes bad. The efficiency of the system is improved by using LED bulbs. A web camera can be included as future scope of work for surveillance purpose.

References

[1] Buratti, C., Conti, A., Dardari, D., Verdone R., "An Overview on Wireless Sensor Networks Technology and Evolution", Sensors, Vol. 9, 2009, pp.6869-6896.

[2] Swati Rajesh Parekar, Manoj M, Dongre, "An intelligent system for monitoring and controlling of street light using GSM technology" International Conference on Information Processing (ICIP), 2015, Pune, 16-19 Dec. 2015.

[3] Gul Shahzad, Heekwon Yang, Arbab Waheed Ahmad, Chankil Lee, "Energy-Efficient Intelligent Street Lighting System using Traffic-Adaptive Control", IEEE Sensors Journal, Vol.16, Issue: 13, July 1, 2016.

[4] Fabiolecces, "Remote-Control System of High Efficiency and Intelligent Street Lighting Using a ZigBee Network of Devices and Sensors", IEEE Transactions on Power Delivery, Vol. 28, Issue: 1, Jan. 2013.

[5] Liuyi Ling, Xiaoliang Wu, Mengyuan Liu, Zhiqiang Zhu, Yan Li, Benben Shang, "Hybrid LED Street Lighting System", Advanced Information Management, Communicates, Electronic and Automation Control Conference (IMCEC), Xi'an, China, 3-5 Oct. 2016.

[6] https://www.raspberrypi.org/

[7] "PIR Motion Sensor", Adafruit Industries, New York, 2016 (https://cdn-learn.adafruit.com).

[8] Cytron Technologies Sdn. Bhd., "User's Manual – HC-SR04 Ultrasonic Sensor", V1.0, May 2013, Malaysia.

[9] Nordic Semiconductor, "nRF24L01 Product specification, 2008.

[10] https://www.arduino.cc

[11] SIMCom, "SIM900A Hardware Design", SIM900A_HD_V1.01, 2009.