IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

Design and Implementation of Smart Street Light Using Solar Power

Dr. Anjali Garg[1], Uttpal Raj[2],

Department of Electrical, Electronics and Communication Engineering, The NorthCap University, Gurugram, Haryana

Abstract

BLE, Bluetooth low energy is low power wireless communication system which is used to build communication for a large no. of devices like cell phones, smartwatches, wireless speakers, etc at the same instance of time. Apple was the first phone to introduce BLE into their smartphone model iphone4s in 2011 and after that it became a fashion for most of the companies to include Bluetooth into their devices for a faster reliable and secure connection. This paper aims to design and implement a system that is used to control a smart street light and also gather the data from the installed sensors using the desired BLE devices and give the application by using both as software application as well as hardware device that should consume low power (take power from free energy source i.e. solar panel). The communication part aims to utilize 2.4 GHz unlicensed ISM band for LED light fitting and sensor networks, and it will make it cost and energy efficient by fulfilling all the requirement of connectivity.

Keywords: Wireless, Bluetooth Low Energy, Connection, Communication, Solar Panel

I.Introduction

Bluetooth low energy is the technology which help the devices to communicate with each other without any extra wires. This technology can be used in other different area like in IoT, security, home automation etc. Bluetooth is a type of non-wired(wireless) technology that helps in exchanging data for a shorter range of distances with the use of shorter wavelengths. The main idea behind the development of Bluetooth is to create a setup that can successfully set up the connections with various other possible peripherals such as mobile phones, computer printer, fax machine, etc. Bluetooth initially came up as an alternative to RS-232 data cable that further helps in building Personal Area Network up to 30 feet [1]. The core system employs frequency hopping with the trans receiver to combat interference and fading techniques.

Previously the speed of data transfer was much slower than the latest version. Bluetooth 1.0 has capability of having 1 Mbps data transfer for about 10 meters. Gaussian Frequency Shift Keying (GFSK) that has a carrier that shifts between frequencies to attain 1mbps speed. Both 2.0 and 2.1 offer a faster PSK modulation scheme P/4 DQPSK and 8DQPSK that offers 2 to 3 times faster data transmission and attain 2 to 3 Mbps speed. Bluetooth was adopted in 2004 and the second version offers a change in waveform phase to carry the information by opposing frequency modulation which results in easier pairing and enhanced data rate. Bluetooth 3.0 was launched in 2008 which has 8 times faster than Bluetooth 2.0 with almost 24 Mbps speed up to 30 feet. Bluetooth 2.0 offers have EDR (Endpoint Detection and Response) and high-speed options to attain instant information service.

Bluetooth Low Energy (BLE) is a low-power wireless communication technology defined by SIG (Special Interest Group). SIG (Special Interest Group) was established in 1998 initially, Bluetooth SIG includes Ericsson, IBM, Intel, Nokia, and Toshiba but later on, it reached nearly 4000 members. by the end of the first year. Bluetooth came up in different versions in the past 21 years with different data speed power consumption capabilities and data transmission range. In 1999, Bluetooth 1.0 launched its first version to create new possible ways to enable devices like fax machines, printers, wireless speakers, and headphones. BLE devices work with interconnections of central element to the slaves that generate command and accept the response of the task while the peripheral receives the command and works on the task. On 30th June 2010, Bluetooth launched its fourth version 4.0 in the market that was linked with various mobile operating systems like ios, Linux, windows phone, and blackberry. Bluetooth sends and receives data with the size 27 to 31 byte at the speed of 1 Mbps up to 10-meter indoor range. BLE 4.0 supports GFSK modulation. In December 2016, Bluetooth launched its most advanced version with better power consumption capability, data rate, and range. Speed of data transmission is up to 2 Mbps, 4 times range i.e. 40 meters indoor environment with large message capacity up to 255 bytes and greater battery life. Now BLE device is capable to support IoT devices. Enhancing the technology Bluetooth took connectivity among the devices to a different level. There is so much advancement in the technology and hence the future of Bluetooth low energy is very bright. the future will be IoT and by configuring BLE with IoT will leads to the too many futuristic applications. Currently, Bluetooth special interest group is working on Bluetooth technology which is most efficient than previous version [1,2].

Low power wide area network (LPWAN) is an innovative concept to create smart city formation. It highly relies on BLE and sensor technology that need a small amount of data for a longer range especially in mesh networking and maintains longer battery life.

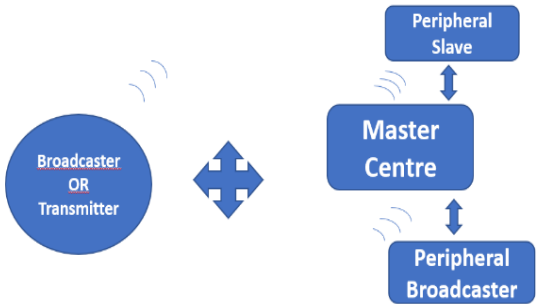

Figure 1: BLE Topology

Bluetooth low energy topology consists of various terminologies and roles. The broadcaster that acts as a transmitter which helps in transmitting the data to the observer/receiver that helps in receiving the data. Peripherals of Nordic chip or development board are compatible with Bluetooth devices which further helps in salve roles. Central is the master that supports multiple connection roles and initiates a connection with other peripheral. Further peripheral is divided into further parts like master-slave with their functionality. To succeed the data transfer there is a server and the client. The server is the formation of peripherals that contain the data and further with the client and a client device is a central device that needs the data to access for evaluation. Peripherals contain memory, radio, controller which are connected to the power supply [3].

Applications of Bluetooth Low Energy

Bluetooth low energy is developed to improvise several applications in the modern period development and in the field of communication. It has made our life easier and flexible communication between the transmitter and the client. There are some applications: -

1. Charging: Latest smartphones come with a wireless charging option which is faster and easier than the earlier method. Also, there can be multiple devices can connect to a Bluetooth charger up to 5 centimetres.
2. Irrigation: Gyujo system which is established by Fuji Stu is an effective example of an advanced BLE application to figure out of best time to inseminate the cow and helps to improve their livelihood. Also, BLE can help in making a smart irrigation system.

3. Mode of Transport: Automobile industry has updated their vehicle with various features. Bluetooth adaptive sensors that help in better parking experience, changing of punctured tires, and wireless connection between devices to make the vehicle smart and improve livelihood easier [2,4].

II. Ideology

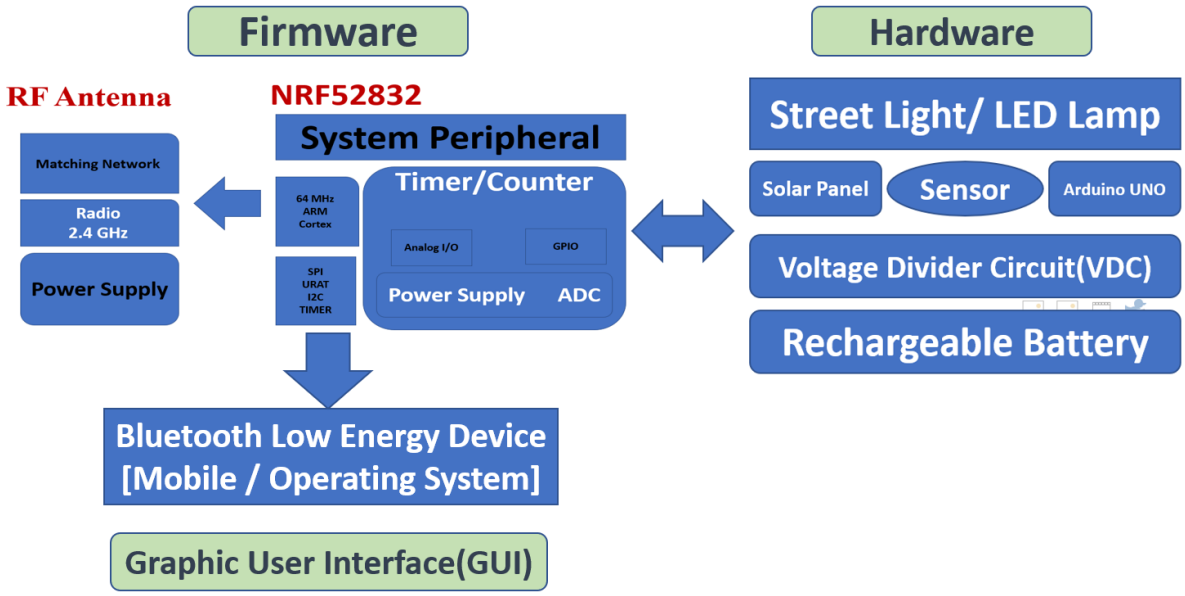

Figure 2: Block diagram of proposed system

The main ideology is to design and implement a system that is used to control a smart street light and also gather the data from the installed sensors using the desired BLE devices and give the application by both as software application as well as hardware device that should consume low power (take power from free energy source i.e. solar panel). The communication part aims to utilize 2.4 GHz unlicensed ISM band for LED light fitting and sensor networks and it will make it cost and energy efficient by fulfilling all the requirement of connectivity.

The system consists of three sections viz Firmware, Hardware and Graphic User Interface (GUI) shown in figure 2. Each section has its own functionality and role. This paper is focused on designing and implementation of Hardware section. The brief detail of each section is given below:

a. Hardware

This flow chart consists of the description of the hardware block by block. There are sets of multiple sensors that contain magnetic, proximity, (Active Infrared Sensor/Passive Infrared Sensor) AIR/ PIR, and the purpose of sensors is to collect data from the environment, digital sensors set straightforward and easy interface with a microcontroller using SPI (Serial Peripheral Interface) bus. Although for analog sensors, either analog-to-digital converter (ADC) or Sigma-Delta modulator is used to convert the data into SPI output. They send analog input to digital output into the next block. The next block consists of nrf52832(Nordic chip) that works as a development board. Nordic's nRF52832 SoC (System on Chip) provides the Bluetooth Low Energy connectivity from the device to a user's Bluetooth 5.0 smartphone for setup, configuration of a network, and sensor adjustments including time delay, ambient light, and other sensitivity, and motion detection range and sensitivity of the information. The power supply converts 220v ac to 5/3.3v dc. The Nordic chip consists of various peripherals like SPI, UART, I2C that perform different specifications.

There is an RF antenna that has a matching network for data transmission at a particular frequency. It includes an NFC antenna that quickly enables the utilization of the NFC-A tag peripheral on the nRF52832. The whole setup sends an output to a smart LED street lights system that can control automatically. It facilitates development by exploiting all features of the nRF52832 SoCs. The ARM Cortex-M family are ARM micro

processor cores that are designed for ASICs, ASSPs, FPGAs, microcontrollers, and SoCs which work on 64 MHz processors. Cortex-M cores are commonly used as microcontroller chips, but also are "set" inside of SoC chips as system controllers, power management controllers, Input/output controllers, screen controllers, battery controllers, and sensors controllers. For transferring a small amount of data, the above set up connected to a BLE device such as an android phone or PC devices that can be used manually [5,7].

b. GUI

Aim of creating a Graphic User Interface (GUI) for controlling the Bluetooth low energy enabled devices and get instant update regarding area-wise working of BLE street light. There was use of JavaScript along with html and CSS to create the front-end user interface and the python programming helps to create backend part of the user interface. Design user-interface which can control the intensity of light without area centric and provide some additional features like informing technicians regarding working of street light and it has an option to user login. GUI can also measure the distance between the street lights [6]. Street light are set in mesh topology and know exactly which street is not working properly.

c. Firmware

This section aims to develop a software in which the hardware can perform its functionality and application.

Solar Power enabled street light

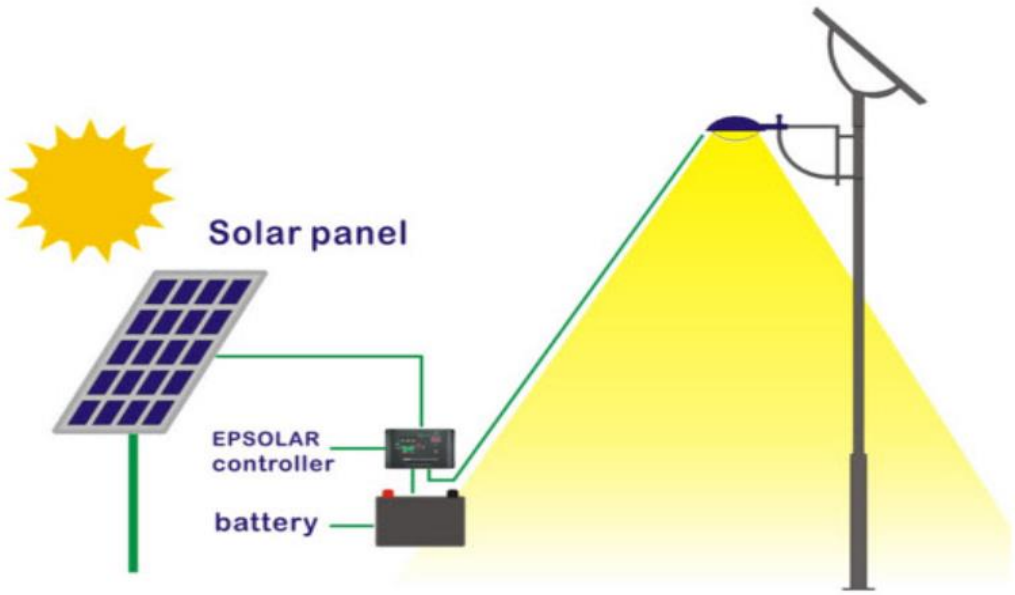

Figure 3: Solar Street Light Working

This diagram gives a particular idea of the approach of the project.

Solar lamps are easier to install and maintain as they do not require much electric cables. Solar lamps can benefit the investors and creators with both reduced maintenance cost and costs of electricity bills. The idea of solar lamps used in areas where there is no electrical grid or remote areas that lack a reliability over electricity supply. Lack of lighting equates to continued poverty felt around the world. By solar energy lamp it converts light energy into electrical energy thereby providing convenience to our daily life.

LED lights are used because of their high luminous efficiency and long-lasting life. With the control of a DC charged controller, wireless control automatically turns on the light at dark and switches off at daytime (when light hits). It also combines with time controller system to set certain time for it to automatically switch light off and on. The light will be shown through the LED when all the required elements are connected.

The energy which is required to power solar lights is obtained completely from the sun. In simple terms, the sun's energy is stored by a series of solar cells (combine in the form of a solar panel) and then converted into desired source and stored into rechargeable batteries. Once they get charged, the batteries can power the lights for night time operation.

All solar lights have a built-in light sensor which allows the energy cycle of charging during the day (when light approaches) and used at night. Instead of always leaving the light in the 'ON' position, now the light will operate automatically. This operation turns the light on at dusk and off when exposed to light or when the battery storage is exhausted, whichever comes first. User can get solar powered lights which can interrupt this cycle such as Proximity Infra-Red sensor remote controlled lights.

PIR enabled solar lights operate only when triggered by a heat source any living body passing through the sensor zone. This operation usually only lasts for small amount of time like seconds or minutes before switching off again. PIR sensor lights are best suited as a security lighting solution where a constant light source is not required [8,9].

III. Modelling and Implementation of Hardware

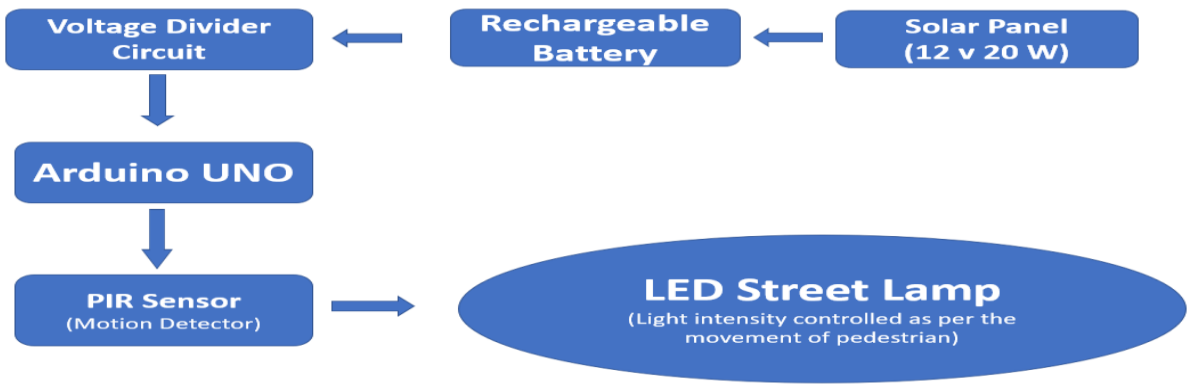

Figure 4:Flow chart of operating LED street lamp using solar energy

This figure shows the flow chart of the street light system. It gives a brief ides of flow and conversion of energy and will give roles of each component. When sun hits the solar panel, a solar panel is a set of solar cells which helps to convert solar energy to the desired energy(electrical) energy. A solar energy is a point of thermal energy. The overall output is measured in terms of kilo watt. Charge controller circuit it is a system that prevent the battery to get high flow of current. A rechargeable battery or accumulator which is used combination electrode material and electrolyte and it is used because of energy can be used even after it gets exhausted where as a primary or non-rechargeable battery is of no use when the energy stored is exhausted. Voltage divider circuit is a fundamental circuit that helps to degrade large voltage range into

smaller one. Arduino UNO is used here for the intensity control of the LED lights. It generates a pulse width modulation wave at particular RTC to give analog and digital input and output that will further interface to street light [10].

Schematic diagram

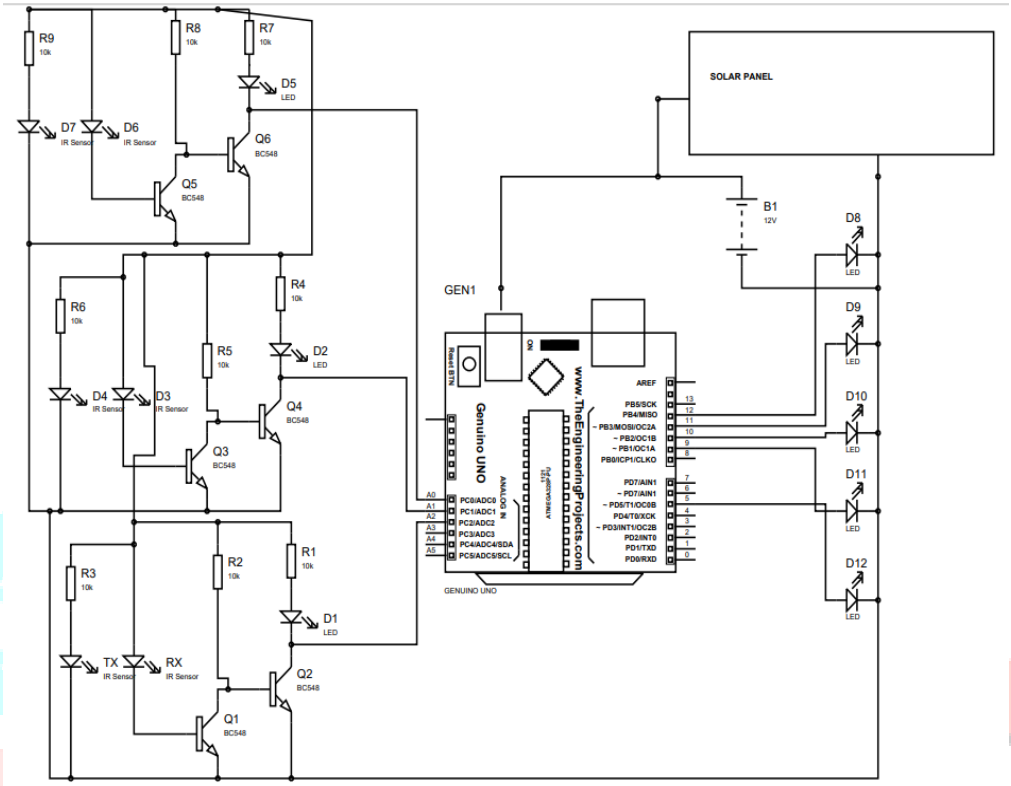

Figure 5: Schematic Diagram of Hardware Section

Solar LED lights: LED light is light emitting diode that comprises of a chemical compound that gives of the light when Direct Current from the battery passes through it. Solar enabled LEDs are available from number of brands in different sizes, shapes, and features. The life of LED is high extending up to 50,000 hours approx. The LEDs require small amount of current and hence the solar panels of smaller sizes are required for the solar lights with the lamps.

The ideology shows optimum results because it has Microcontroller (Arduino UNO) based constant current LED driver, Maximum power point tracking charger, solar panel for inevitable energy source, Light intensity programme using different LED and Temperature compensator battery charging. Some special benefits include the intensity which can be controlled and easy installation specially at rural area. Smaller solar battery size is used in smart street lights as intensity decreases after midnight. Installation of normal street light in villages and rural areas where normal grid electricity is not available at all the times is sometimes not feasible and hence using solar lights helps to resolve this issue.

To calculate the electricity generated as an output of photovoltaic system equation (1) is used.

$$E = A \times r \times H \times PR \quad \ldots\ldots (1)$$

Where, E is Energy (kWh), A is the total Area of the panel (m^2), r is the solar panel yield (%), H is an annual average solar radiation on tilted panels and PR is the Performance ratio, constant for losses (range lies between 0.5 and 0.9, default value is 0.75). Here r is the yield of the solar panel which is given by: r= electrical power (in kWh) of one solar panel divided/ by the area of one of the panel [4,11]. This technology

provides individual panels for each lamp of a system and have a large central solar panel and a battery bank to power multiple lamps [12].

IV.Conclusion

The paper presents the design and implement of a system that enable the sensors to transfer the signal and set up communication. The present situation is that a person has to switch off and on the street light as per the need in night time and in morning time. It became very hectic for a person to do it on a regular basis. It also has huge amount of electrical power wastage. With the help of Bluetooth technology, the implementation is very easy and affordable. These lights provide a convenient and cost-effective way to light streets at night without the need of AC electrical grids for pedestrians and drivers. They have individual panels for each lamp of a system and have a large central solar panel and a battery bank to power multiple lamps.

References:-

[1] Hui, J.W. and Culler, D.E. "Extending IP to low-power, wireless personal area networks". IEEE Internet Comput. **(2008)**, no.12, pp.37–45.Gomez, C. and Paradells, J. "Wireless home automation networks: A survey of architectures and Technologies". IEEE Commun. Mag. **(2010)**, no.48, pp. 92–101.
[2] Callegati, F., Cerroni, W. and Ramili, M. "Man-in-the-Middle attack to the HTTPS protocol". IEEE Secur. Priv. **(2009)**, no.7,pp.78–81.
[3] Gomez, C. and Paradells, J. "Wireless home automation networks: A survey of architectures and Technologies". IEEE Commun. Mag. **(2010)**, no.48, pp. 92–101.
[4] Nieminen, J., Patil, B., Savolainen, T., Isomaki, M.,Shelby, Z. and Gomez, C. "Transmission of IPv6 packets over Bluetooth low energy" draft-ietf-6lowpan-btle-08. **(2012)**, in preparation.
[5] Zheng, J., Lee, M.J. and Anshel, M. "Towards secure low rate wireless personal area networks". IEEE Trans. Mob. Comput. **(2006)**, no.5, pp.1361–1373.
[6] Echevarría, J.J., Ruiz-de-Garibay, J., Legarda, J., Álvarez, M., Ayerbe, A. and Vázaquez, J.I. WebTag: "Web browsing into sensor tags over NFC". Sensors **(2012)**,no. 12, pp.8675–8690.
[7] R. Santhosh Kumar, Dr. Prabu, S. Vijaya Rani and P. Venkatesh 2015. Design and Implementation of an Automatic Solar Panel Based Led Street Lighting System Using Zigbee and Sensor, MiddleEast Journal of Scientific Research 23 (4): 573-579, 2015.
[8] Dudhe, P.V.; Kadam, N.V.; Hushangabade, R.M.; Deshmukh, M.S. Internet of Things (IOT): An overview and its applications. In Proceedings of the 2017 International Conference on Energy, Communication, Data Analytics and Soft Computing (ICECDS), Chennai, India, 1–2 August 2017.

[9] Fortino, G.; Gravina, R.; Galzarano, S. Wearable Computing: From Modeling to Implementation of Wearable Systems Based on Body Sensor Networks; John Wiley & Sons, Inc.: Hoboken, NJ, USA, 2018; ISBN 9781119078821.

[10] Sarr, Y.; Gueye, B.; Sarr, C. Performance Analysis of a Smart Street Lighting application using LoRaWan. In Proceedings of the 2019 International Conference on Advanced Communication Technologies and Networking (CommNet), Rabat, Morocco, 12–14 April 2019.

[11] Hannan, S.; Humayun Kabir, M.; Uddin, M.J. A Case Study on a Proposed Adaptive and Energy Efficient Street Lighting System for Chittagong City. In Proceedings of the 1st International Conference on Advances in Science, Engineering and Robotics Technology 2019 (ICASERT 2019), Dhaka, Bangladesh, 3–5 May 2019.

[12] B. Abinaya, S. Gurupriya, and M. Pooja, "IoT Based ASED Smart and Adaptive Lighting in Street Lights". Second International Conference on Computing and Communications Technologies (ICCCT'17), 2017.